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Special Report
Geophysical Activity in 1981

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Special Report
Geophysical Activity in 1981

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Report of the SEG Geophysical Activity Committee. Members of the Committee are Russell J. Senti, Chairman; W. E. Blakeley, H. R. Espey, R. R. Hartman, David A. Hastings, Richard Hopkins, William C. Kellogg, Fritz P. Kronberger, James R. McBeth, Gerald E. Montgomery, H. Roice Nelson, Jr., T. R. Salisbury, Betty Stone, Wayne Suyenaga, Tommy A. Tillery, and A. H. Watts.

Introduction

This report presents statistical data on worldwide geophysical activity in 1981. The data were gathered from survey questionnaires that were completed by more than 500 companies, contractors, government agencies, and institutions throughout the free world. We have attempted to gather data from all users of geophysical techniques in the areas of petroleum, mining, geothermal, and groundwater exploration and from those who employ geophysical methods in engineering, oceanography, and research. In general, response to the survey was good. However, we still feel that there are new users of geophysical techniques we are not reaching. If you did *not* receive our 1981 questionnaires, please let us know so we can include you on our mailing list for 1982. (As always, data submitted by individual organizations are held *strictly* confidential.)

Detailed information was gathered on airborne, drill hole, land, and marine geophysical surveys. Statistics were compiled on miles of coverage, number of stations, drill hole footage, time spent in crew-months or man-months, and acquisition costs. Data not supplied on the questionnaires by the respondent were estimated on the basis of massive statistical averaging for the area and techniques reported. This process is necessary to avoid distortion of individual statistical items.

This report, when compared to past annual reports, provides a basis for detecting and analyzing trends in technological developments and exploratory trends in geographical areas. Changes in these trends reflect the influence of many factors, such as technological advances, inflation, government regulations, and exploration philosophy. Cost figures are sensitive to many factors, such as operational environment, length and nature of the

Table 1. Total worldwide expenditures in US$ (thousands) by survey type and objective.

Type	Petroleum[1]	Minerals	Engineering	Geothermal	Groundwater	Oceanography	Research	Total
Land	2,717,930	19,406	4,494	4,314	4,499		5,209	2,755,852
Marine	1,192,685		7,645			5,187	2,932	1,208,449
Airborne	17,085	43,122		5,718		1,107	974	68,006
Drill hole	383	2,923	935	3,642	72		194	8,149
Total	3,928,083	65,451	13,074	13,674	4,571	6,294	9,309	4,040,456

[1]Includes processing and interpretation costs for land and marine. See text for details.

Note: All tables in this report where figures are expressed in thousands of dollars have been rounded off as individual items; but the computer keeps track of all the truncated numbers and then the sums of the individual items are rounded off. As a result of this procedure, the rounded individual items may not add up precisely to the rounded sums.

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Table 2. Total worldwide expenditures in US$ (thousands) by area and survey objective.

Area	Petroleum[1]	Minerals	Engineering	Geothermal	Groundwater	Oceanography	Research	Total
International	12,961					500	2,244	15,705
U.S.A.	1,750,470	6,404	5,012	7,225	642	1,350	4,554	1,775,657
Canada	301,308	17,032	237	200		360	692	319,829
Mexico	135,908	2,152		100			100	138,260
South America	355,774	1,615	212	15	21	790	95	358,522
Europe	364,933	7,968	4,088		220		352	377,561
Africa	388,915	13,972	1,928		3,648	1,127	8	409,598
Middle East	197,904	1,055	25					198,984
Far East	203,913	672	1,567	6,134		2,167		214,453
Australia/ New Zealand	215,997	14,581	5		40		1,264	231,887
Total	3,928,083	65,451	13,074	13,674	4,571	6,294	9,309	4,040,456

[1]Includes processing and interpretation costs.

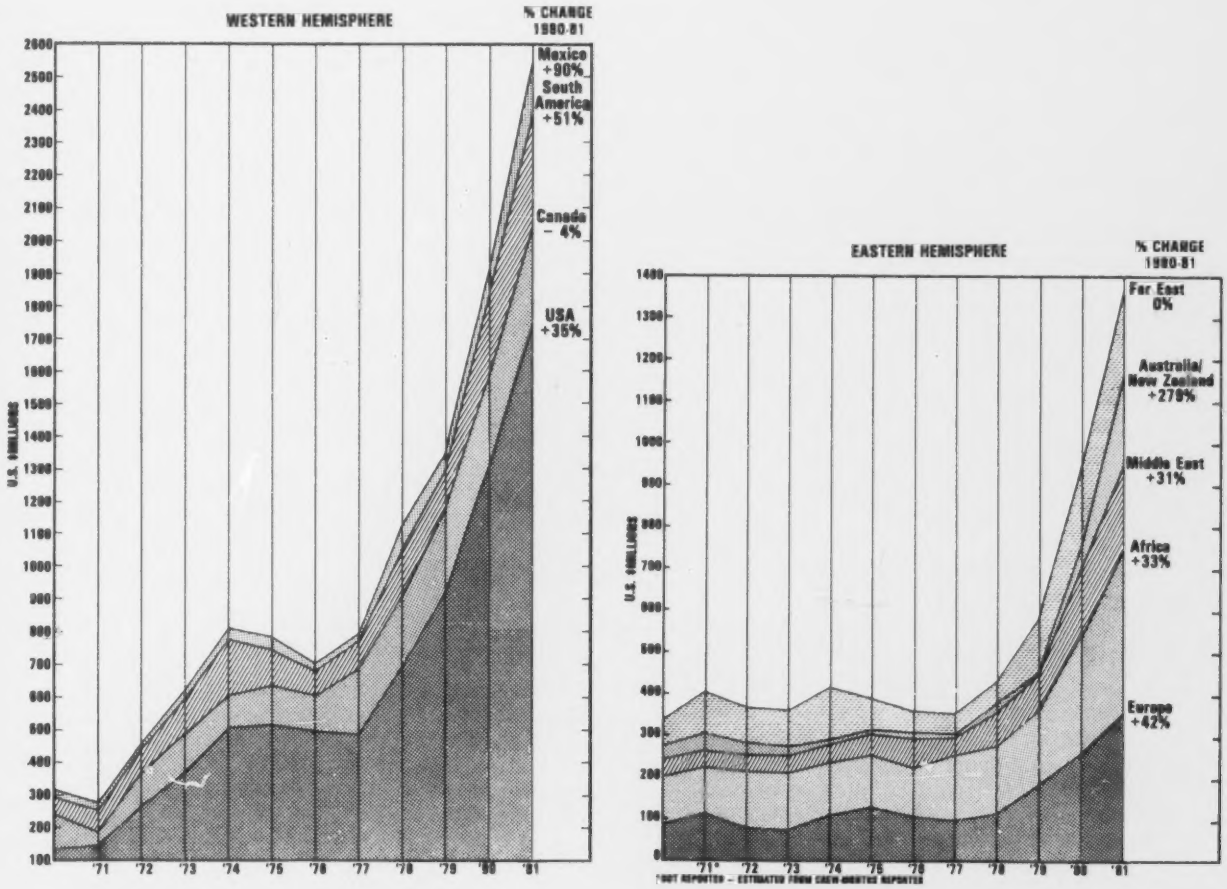

FIG. 1 Total expenditures on petroleum exploration, 1970-1981.

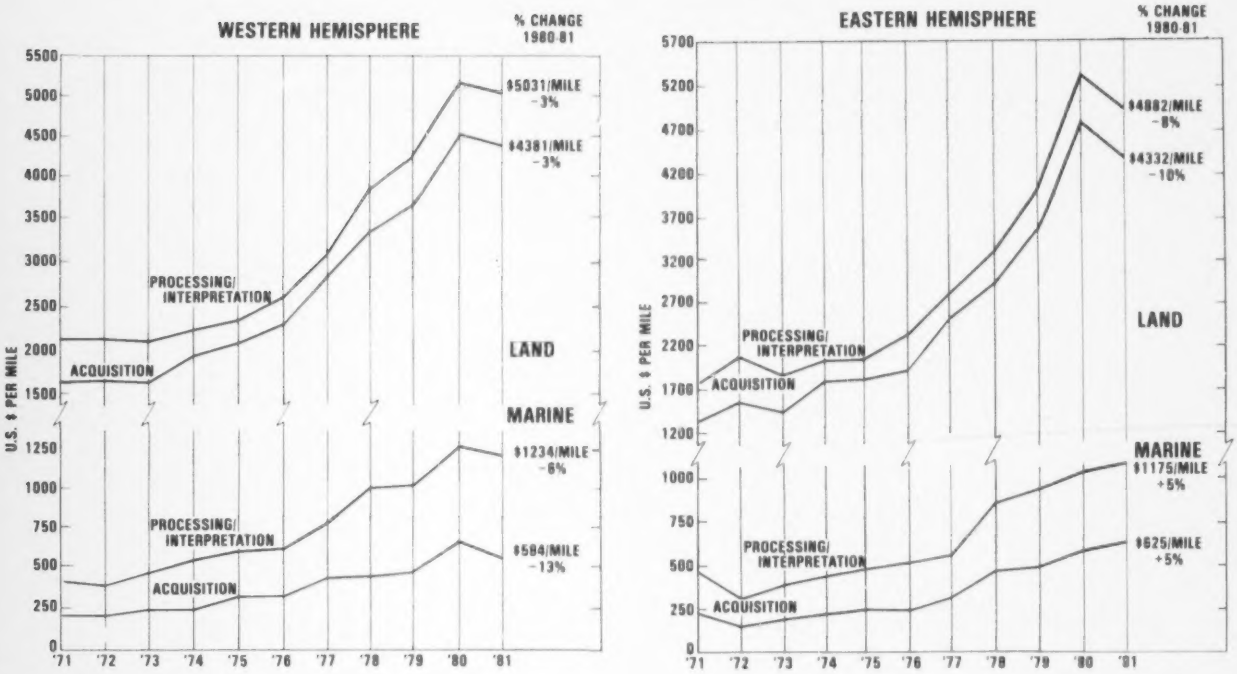

FIG. 2 Average cost per mile for petroleum surveys, 1971-1981.

Table 3. Worldwide petroleum land seismic activity.

Area	Acquisition costs (US$)	Line-miles	Crew-months* Company	Crew-months* Contract	Crew-months total*	Average mile/month	Average cost/month	Average cost/mile
U.S.A.	1,138,539,470	256,201	932.2	4,489.1	5,421.3	47	210,012	4,443
Canada	157,417,800	40,178	47.0	457.4	504.4	79	312,089	3,918
Mexico	88,226,079	30,837		364.8	364.8	84	241,847	2,861
South America	243,096,084	44,208	2.0	807.4	809.4	54	300,341	5,498
Europe	126,056,036	25,564		529.7	529.7	48	237,976	4,930
Africa	255,590,431	62,611	6.0	866.7	872.7	71	292,873	4,082
Middle East	141,096,039	32,970		411.5	411.5	80	342,882	4,279
Far East	108,082,402	16,796		345.4	345.4	48	312,919	6,435
Australia/ New Zealand	112,912,010	33,746		315.2	315.2	107	358,223	3,345
Total	2,371,016,351	543,111	987.2	8,587.2	9,574.4	56	247,641	4,365

*Total includes government and university activity.

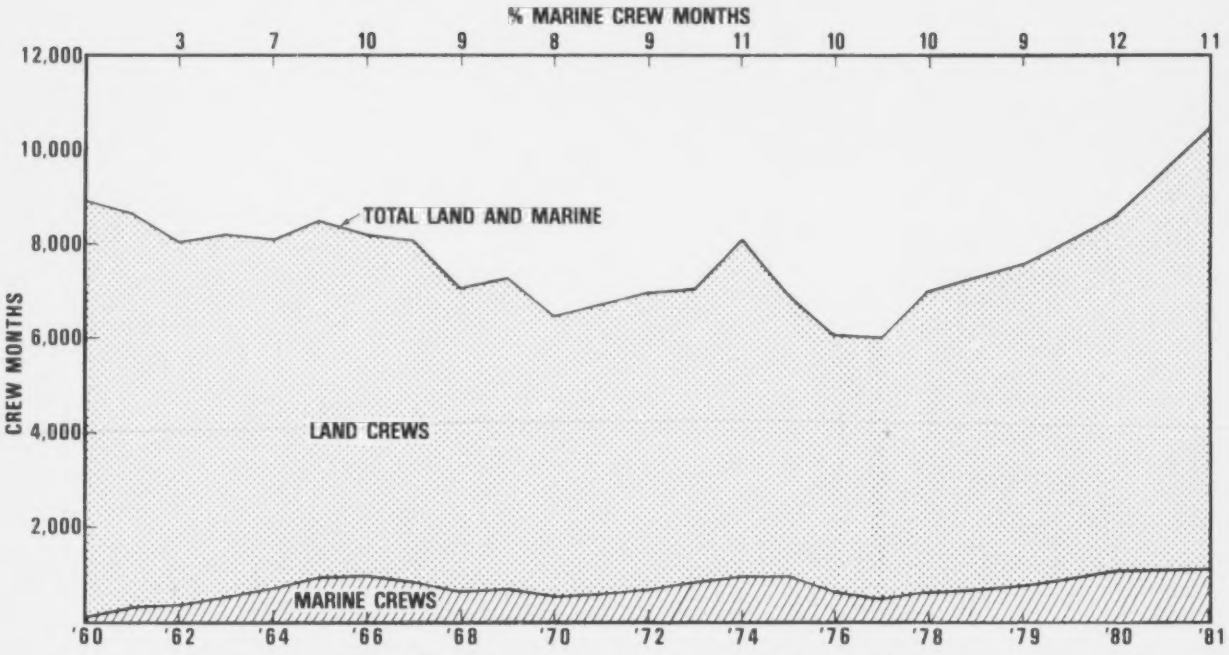

FIG. 3 Worldwide seismic activity in crew-months, 1960-1981.

survey, type of instrumentation, etc. Unit costs reported by universities are substantially lower than those reported by industry due to the use of student labor and donated equipment. These costs, however, must be averaged with industry costs to accommodate the format of the report. Therefore, when examining unit cost figures, one must be cognizant of the broad spectrum of activity embraced by individual categories.

1981 highlights

Worldwide expenditures on geophysical exploration were up approximately 35 percent from last year, reaching an all-time record high of US $4 billion (see Table 1). The increase came primarily in the petroleum area, up 35 percent (over US $1 billion). Geothermal activity more than doubled (up 116 percent), due to a significant increase in airborne work. Expenditures reported for groundwater, oceanography, and mining were up 2, 14, and 22 percent, respectively, while reports of money spent on research and engineering were down 9 and 13 percent. Like geothermal, most of the increase in oceanography and mining was in airborne work. The decline in research and engineering activity is believed due to incomplete information. We suspect that these areas are still under-reported.

Distribution of expenditures by geographic area and survey objective is shown in Table 2. Approximately 44 percent of all expenditures for geophysical work was spent in the United States. All areas showed an increase in expenditures over 1980 except Canada. Canada declined 3 percent while the U.S. increased 34 percent. The slight decline in Canada can be attributed to a continuation from last year of less land seismic activity. (Canadian marine seismic activity was up over 100 percent.) The Far East, Middle East, Africa, Europe, South America, and Mexico had increases of 4, 31, 33, 38, 50, and 89 percent, respectively, while Australia/New Zealand had the largest percent increase (264 percent) for the second year in a row.

The cost of processing and interpretation are included in Figures 1 and 2 and the petroleum column of Tables 1 and 2. All other tables show acquisition costs *only*. This year two additional columns (one for processing costs and one for interpretation costs) were added to our questionnaires. It was hoped we could obtain more detailed data for these costs. Unfortunately, less than 10 percent of the companies and contractors responded. I did use this small bit of data, combined with my own best estimates to arrive at the following figures: US $650 per line-mile was used for the Western Hemisphere and US $550 per line-mile was used for the Eastern Hemisphere. The higher cost in the Western Hemisphere is based on the premise that, in general, a more rigorous processing and interpretation treatment is required because of the subtle structural and stratigraphic prospects that may be economically viable objectives in much of the Western Hemisphere but are not usually primary targets in much of the Eastern Hemisphere.

Petroleum exploration

Over 97 percent of all geophysical dollars were spent on petroleum exploration (US $3.9 billion) in 1981. Expenditures in the U.S. increased 35 percent while Mexico increased nearly 90 percent. South America showed a 51 percent and Europe a 42 percent increase, while Australia/New Zealand rose over 279 percent compared to 1980. Geophysical activity in the Western

Table 4. Worldwide petroleum land seismic line-miles by energy source.

Area	Dynamite	Compressed air	Gas exploder	Weight drop	Solid chemical	Vibrator	Other	Total line-miles
U.S.A.	123,958	18,999	3,404		400	109,002	438	256,201
Canada	29,523	604				9,786	265	40,178
Mexico	17,019	556				13,262		30,837
South America	21,677					22,531		44,208
Europe	12,148	80				12,317	1,019	25,564
Africa	32,877			10,991		18,554	189	62,611
Middle East	7,614			4,277		21,079		32,970
Far East	15,386					1,240	170	16,796
Australia/ New Zealand	4,117	497		209	9,000	19,908	15	33,746
Total	264,319	20,736	3,404	15,477	9,400	227,679	2,096	543,111

Table 5. Worldwide petroleum marine seismic activity.

Area	Acquisition costs (US$)	Line-miles	Crew-months* Company	Crew-months* Contract	Crew-months total*	Average mile/month	Average cost/month	Average cost/mile
International	12,961,461	18,268		20.7	20.7	882	626,157	709
U.S.A.	205,139,825	338,201	106.1	349.9	456.0	741	449,868	606
Canada	56,273,036	93,688		79.1	79.1	1,184	711,416	600
Mexico	8,411,000	29,581		15.0	15.0	1,972	560,733	284
South America	37,040,349	63,885	6.8	64.7	71.5	893	518,046	579
Europe	104,871,616	214,089	12.9	190.8	203.7	1,051	514,833	489
Africa	49,831,160	76,357	9.5	90.4	99.9	764	498,810	652
Middle East	20,095,037	31,373	.2	40.7	40.9	767	491,321	640
Far East	47,528,259	68,500		90.3	90.3	758	526,337	693
Australia/ New Zealand	55,110,000	53,477		54.0	54.0	990	1,020,555	1,030
Total	597,261,743	987,419	135.5	995.6	1,131.1	872	528,036	604

*Total includes government and university activity.

Table 6. Worldwide petroleum marine seismic line-miles by energy source.

Area	Compressed air	Electrical	Gas exploder	Implosive	Solid chemical	Other	Total line-miles
International	18,268						18,268
U.S.A.	228,827	7,800	90,044	11,530			338,201
Canada	93,230		458				93,688
Mexico	4,422					25,159	29,581
South America	46,222		17,663				63,885
Europe	139,433		37,928	29,528	7,200		214,089
Africa	38,095		4,000	23,862	10,400		76,357
Middle East	8,973		14,400		8,000		31,373
Far East	33,300		35,200				68,500
Australia/ New Zealand	53,477						53,477
Total	664,247	7,800	199,693	64,920	25,600	25,159	987,419

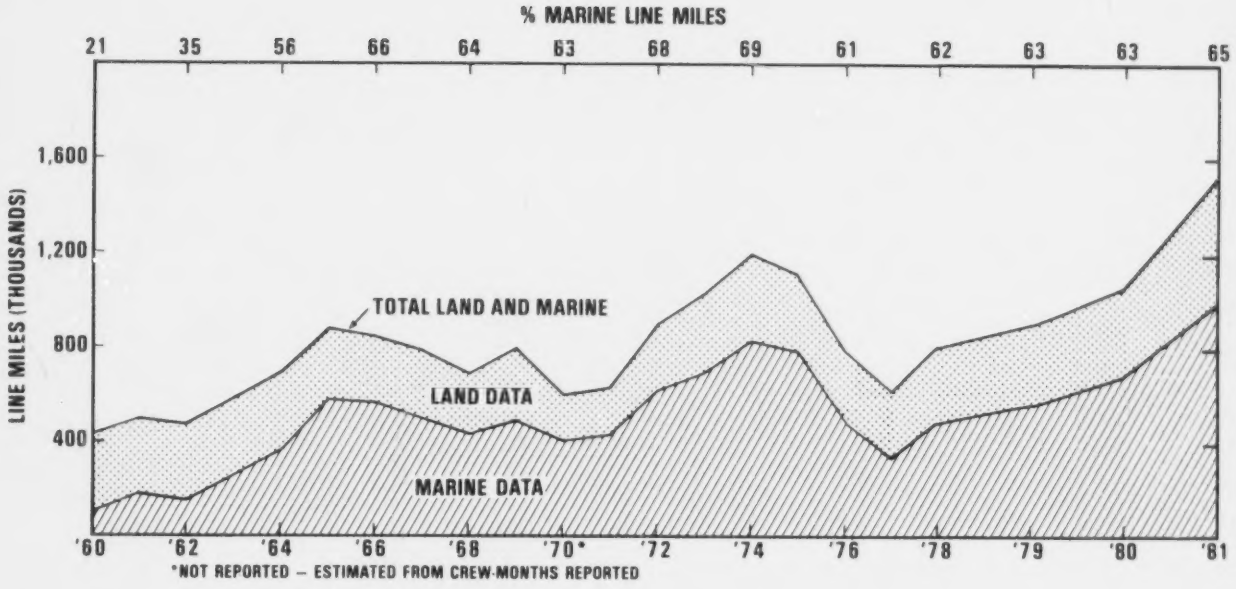
% MARINE LINE MILES
21 35 56 66 64 63 68 69 61 62 63 63 65
LINE MILES (THOUSANDS)
1,600
1,200
800
400
TOTAL LAND AND MARINE
LAND DATA
MARINE DATA
'60 '62 '64 '66 '68 '70* '72 '74 '76 '78 '79 '80 '81
*NOT REPORTED – ESTIMATED FROM CREW-MONTHS REPORTED

FIG. 4 Worldwide seismic activity in line-miles, 1960-1981.

Hemisphere increased 32 percent while the Eastern Hemisphere rose 43 percent.

A 10-year history of geophysical activity in both the Western and Eastern Hemispheres is shown in Figure 1.

Seismic surveys

The seismic method accounted for over 95 percent of all expenditures in geophysical activity. This statistic, plus the strong tendency for wildcatting to follow and parallel seismic activity, has caused those interested in forecasts of petroleum exploration to regard seismic activity as the barometer for exploration. A 10-year history of the cost of petroleum seismic surveys in both the Eastern and Western Hemispheres is shown in Figure 2. In the Western Hemisphere, the acquisition cost per mile of land seismic surveys declined 3 percent, while marine costs dropped 13 percent. In the Eastern Hemisphere, acquisition costs per mile for land seismic decreased 10 percent, while marine costs rose about 5 percent. It seems the greatly increased activity has reversed the trend of increasing cost per mile.

The total number of miles of seismic data recorded worldwide was up 39 percent on land and 50 percent in marine work (see Tables 3 and 5). Group seismic surveys and speculation surveys are still very popular. Operators, reacting to increasing costs of gathering data, choose to sacrifice the competitive advantages of proprietary data for the low cost of nonproprietary data.

The most popular land seismic energy source is dynamite, but Vibroseis methods saw a 48.5 percent increase (in total crew months worked) over 1980. Together these two energy sources account for 90.6 percent of all seismic land work. Air guns and gas exploders captured 87 percent of all the marine work (see Tables 4 and 6).

A more comprehensive breakdown of statistical data on petroleum surveys, sorted by geographic area, can be seen in Table 7. Table 8 shows petroleum seismic activity by states in the U.S. Several states showed more than 100 percent increase in the total number of crew months worked in 1981 over last year. They include Alaska, Arkansas, Florida, Ohio, and Oregon. Other states showing large gains were Michigan, Montana, and Oklahoma. Canadian land activity (Figure 9) has been dropping for the past two years; however, marine activity in 1981 is up nearly 180 percent. Mexico (Table 10) shows a sizable increase of 122 percent over 1980. This large increase might reflect an under-reported condition in prior years.

A 49-year history of seismic exploration in the U.S. is shown In Figure 5. This information is compiled by the SEG Business Office. Data for this graph are gathered monthly by telephone.

Gravity and magnetic surveys

Table 11 shows worldwide expenditures for gravity and magnetic surveys. The 1981 data show a 35 percent decrease in the use of these tools compared to last year. However, I reviewed last year's data and discovered an anomalous US $47.9 million spent on petroleum marine gravity work. If you back this amount out of the 1980 report, then this year's activity shows a 46 percent increase.

(Text continued on p. 21)

Table 7. Worldwide average unit costs for petroleum surveys.

Area, survey type, and method	Total crew-months* or (man-months)	Line-miles or [no. of stations]	Acquisition costs(US$)	Average miles or [no of stations]/ month or (man-months)	Average cost/month or (cost/ man-month)	Average cost/mile or [no. of stations]
International						
Marine						
Seismic (P-wave)						
Compressed air	20.7	18,268	12,961,461	882	626,157	709
U.S.A.						
Land						
Seismic (P-wave)						
Dynamite	2,863.8	114,570	615,647,732	40	214,975	5,373
Compressed air	88.3	18,617	26,158,139	210	296,241	1,405
Gas exploder	75.6	3,404	12,796,355	45	169,263	3,759
Solid chemical	12.0	400	800,000	33	66,666	2,000
Vibratory	2,136.6	105,888	425,887,447	49	199,329	4,022
Other	14.5	438	2,210,026	30	152,415	5,045
Seismic (S-wave)						
Dynamite	183.2	9,388	41,500,000	51	226,528	4,420
Compressed air	12.0	382	1,300,000	31	108,333	3,403
Vibratory	50.0	3,111	12,168,371	62	243,367	3,911
Seismic (refraction)						
Vibratory	0.3	3	71,400	10	238,000	23,800
Gravity	193.1	49,639	5,259,000	257	27,234	105
Gravity	58.3	[19,219]	3,608,578	[330]	61,897	[188]
Self-potential	(2.0)	5	45,500	(3)	(22,750)	9,100
Induced polarization	31.4	609	1,241,165	19	39,527	2,038
Remote-sns other	0.5	50	264,000	100	528,000	5,280
Magnetotelluric	12.0	66	568,000	5	47,333	8,606
Magnetotelluric	8.9	[354]	955,800	[40]	107,393	[2,700]
Marine						
Seismic (P-wave)						
Compressed air	289.0	228,812	142,976,761	791	494,729	624
Electrical	7.2	7,800	2,260,000	1,083	313,888	289
Gas exploder	145.6	90,044	52,264,564	618	358,959	580
Implosive	17.7	11,530	7,494,500	651	423,418	650
Seismic (refraction)						
Compressed air	0.5	15	144,000	30	288,000	9,600
Gravity	24.0	30,000	550,000	1,250	22,916	18
Airborne						
Magnetic	52.6	333,093	6,399,040	6,332	121,654	19
R-S side-scan radar	1.9	208,350§	1,538,000	109,657§	809,473	7
Canada						
Land						
Seismic (P-wave)						
Dynamite	337.4	29,523	119,299,316	87	353,584	4,040
Compressed air	9.2	604	3,938,349	65	428,081	6,520
Vibratory	150.3	9,786	32,717,635	65	217,682	3,343
Other	7.5	265	1,462,500	35	195,000	5,518
Gravity	10.0	800	550,000	80	55,000	687
Induced Polarization	3.0	11	54,563	3	18,187	4,960

*Total includes government and university activity. §Square miles

Table 7. Worldwide average unit costs for petroleum surveys, cont.

Area, survey type, and method	Total crew-months* or (man-months)	Line-miles or [no. of stations]	Acquisition costs(US$)	Average miles or [no of stations]/month or (man-months)	Average cost/month or (cost/man-month)	Average cost/mile or [no. of stations]
Canada, cont.						
Marine						
Seismic (P-wave)						
Compressed air	78.5	93,230	55,989,000	1,187	713,235	600
Gas exploder	0.6	458	284,036	763	473,393	620
Mexico						
Land						
Seismic (P-wave)						
Dynamite	210.9	17,019	45,274,079	80	214,670	1,660
Compressed air	12.0	556	3,565,000	46	297,083	6,411
Vibratory	141.9	13,262	39,387,000	93	277,568	2,969
Marine						
Seismic (P-wave)						
Compressed air	3.0	4,422	2,706,000	1,474	902,000	611
Other	12.0	25,159	5,705,000	2,096	475,416	226
South America						
Land						
Seismic (P-wave)						
Dynamite	502.1	21,677	165,433,283	43	329,482	7,631
Vibratory	307.3	22,531	77,662,801	73	252,726	3,446
Gravity	3.7	503	78,000	135	21,081	155
Resistivity	1.0	15	10,000	15	10,000	666
Induced polarization	10.5	610	1,050,000	58	100,000	1,721
Marine						
Seismic (P-wave)						
Compressed air	49.7	46,222	26,509,439	930	533,389	573
Gas exploder	21.8	17,663	10,530,910	810	483,069	596
Airborne						
Magnetic	23.1	207,245	4,239,000	8,971	183,506	20
Europe						
Land						
Seismic (P-wave)						
Dynamite	267.1	12,148	71,282,764	45	266,876	5,867
Compressed air	0.9	80	562,500	88	625,000	7,031
Vibratory	229.1	12,317	48,587,772	53	212,081	3,944
Other	32.6	1,019	5,623,000	31	172,484	5,518
Gravity	6.0	1,200	240,000	200	40,000	200
Induced polarization	8.5	510	850,000	60	100,000	1,666
Marine						
Seismic (P-wave)						
Compressed air	101.9	139,433	59,926,551	1,368	588,091	429
Gas exploder	47.7	37,928	21,830,165	795	457,655	575
Implosive	45.1	29,528	19,154,900	654	424,720	648
Solid chemical	9.0	7,200	3,960,000	800	440,000	550
Gravity	8.3	10,240	410,000	1,233	49,397	40
Magnetic	1.1	1,321	26,072	1,200	23,701	19

*Total includes government and university activity.

Table 7. Worldwide average unit costs for petroleum surveys, cont.

Area, survey type, and method	Total crew-months* or (man-months)	Line-miles or [no. of stations]	Acquisition costs(US$)	Average miles or [no of stations]/ month or (man-months)	Average cost/month or (cost/ man-month)	Average cost/mile or [no. of stations]
Europe, cont.						
Airborne						
Magnetic	2.7	11,480	290,000	4,251	107,407	25
Drill hole						
Sonic/velocity logging	(52.5)	**	380,625	**	(7,250)	**
Africa						
Land						
Seismic (P-wave)						
Dynamite	491.1	32,691	160,639,651	66	327,101	4,913
Weight drop	116.1	10,991	25,056,638	94	215,819	2,279
Vibratory	243.3	18,554	65,575,596	76	269,525	3,534
Other	4.7	165	916,500	35	195,000	5,554
Seismic (refraction)						
Dynamite	3.5	186	1,395,000	53	398,571	7,500
Other	14.0	24	2,007,046	1	143,360	83,626
Gravity	13.0	4,000	1,300,000	307	100,000	325
Gravity	5.0	[4,500]	3,000,000	[900]	600,000	[667]
Induced polarization	3.5	210	350,000	60	100,000	1,666
Marine						
Seismic (P-wave)						
Compressed air	45.1	38,095	26,400,710	844	585,381	603
Gas exploder	5.0	4,000	2,200,000	800	440,000	550
Implosive	36.8	23,862	15,510,450	648	421,479	650
Solid chemical	13.0	10,400	5,720,000	800	440,000	550
Gravity	2.4	3,441,71,000	1,433	29,583	20	
Magnetic	2.0	2,479	48,930	1,239	24,465	19
Airborne						
Magnetic	21.5	119,521	2,291,630	5,559	106,587	19
Middle East						
Land						
Seismic (P-wave)						
Dynamite	112.8	7,614	42,377,220	67	375,684	5,565
Weight drop	38.0	4,277	12,056,160	112	317,267	2,818
Vibratory	260.7	21,079	86,662,659	80	332,422	4,111
Gravity	1.6	165	32,000	103	20,00	1934
Marine						
Seismic (P-wave)						
Compressed air	12.9	8,973	7,775,037	695	602,716	866
Gas exploder	18.0	14,400	7,920,000	800	440,000	550
Solid chemical	10.0	8,000	4,400,000	800	440,000	550
Gravity	0.1	52	1,050	520	10,500	20
Airborne						
Magnetic	4.1	29,620	1,289,350	7,224	314,475	43
Drill hole						
Sonic/velocity logging	(.4)	**	3,900	**	(7,250)	**

*Total includes government and university activity. **Not applicable.

Table 7. Worldwide average unit costs for petroleum surveys, Cont.

Area, survey type, and method	Total crew-months* or (man-months)	Line-miles or [no. of stations]	Acquisition costs(US$)	Average miles or [no of stations]/ month or (man-months)	Average cost/month or (cost/ man-month)	Average cost/mile or [no. of stations]
Far East						
Land						
Seismic (P-wave)						
Dynamite	325.5	15,386	104,158,431	47	319,995	6,769
Vibratory	15.0	1,240	2,968,471	82	197,898	2,393
Other	4.9	170	955,500	34	1295,000	5,620
Induced polarization	3.5	210	350,000	60	100,000	1,666
Marine						
Seismic (P-wave)						
Compressed air	46.3	33,300	28,168,259	719	608,385	845
Gas exploder	44.0	35,200	19,360,000	800	440,000	550
Airborne						
Magnetic	4.5	24,432	705,310	5,429	156,735	28
R-S side-scan radar	0.4	2,600§	333,400	6,500	833,500	128
Australia/New Zealand						
Land						
Seismic (P-wave)						
Dynamite	47.6	4,117	8,898,399	86	186,941	2,161
Compressed air	1.0	497	759,000	497	759,000	1,527
Weight drop	6.0	209	917,758	34	152,959	4,391
Solid chemical	75.0	9,000	37,620,000	1209	501,600	4,180
Vibratory	190.1	19,908	64,646,853	104	340,067	3,247
Gravity	(1.0)	50	3,000	(50)	(3,000)	60
Other	1.0	15	70,000	15,70,000	4,666	
Marine						
Seismic (P-wave)						
Compressed air	54.0	53,477	55,110,000	990	1,020,555	1,030

*Total includes government and university activity. §Square miles

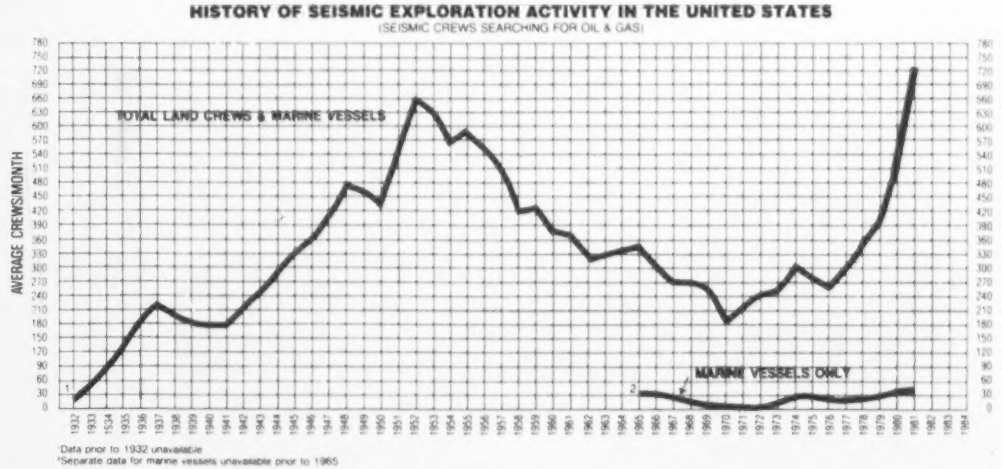
HISTORY OF SEISMIC EXPLORATION ACTIVITY IN THE UNITED STATES
(SEISMIC CREWS SEARCHING FOR OIL & GAS)
TOTAL LAND CREWS & MARINE VESSELS
MARINE VESSELS ONLY
AVERAGE CREWS/MONTH
1
2
Data prior to 1932 unavailable
*Separate data for marine vessels unavailable prior to 1965

FIG. 5 History of seismic exploration activity in the U.S., 1932-1981. The total crews working in a given year is not synonymous with the crew-months worked that year.

Table 8. U.S.A. petroleum seismic activity by area.

State	Acquisition costs (US$)	Line-miles	Crew-months* Company	Crew-months* Contract	Total months
Land					
Undesignated	63,047,500	26,640	.0	239.7	239.7
Alaska	86,844,710	10,025	.0	82.3	82.3
Alabama	25,937,203	6,288	21.6	134.1	155.7
Arkansas	11,711,755	3,128	17.0	49.7	66.7
Arizona	6,425,442	1,224	1.3	31.7	33.0
California	28,329,775	8,488	27.5	164.9	192.4
Colorado	11,518,373	2,243	17.5	38.6	56.1
Florida	7,576,102	2,102	4.0	38.3	42.3
Georgia	963,412	322	.0	6.8	6.8
Idaho	2,846,448	640	1.5	16.3	17.8
Illinois	2,338,000	447	.0	9.0	9.0
Kansas	13,321,548	3,678	1.0	64.2	65.2
Kentucky	1,957,535	419	.0	12.3	12.3
Louisiana	105,473,915	20,430	126.7	374.1	500.8
Maryland	597,000	139	.0	6.0	6.0
Michigan	36,163,215	9,544	17.0	221.9	238.9
Mississippi	32,398,007	6,415	44.2	130.8	175.0
Montana	85,118,528	20,340	30.9	356.7	387.6
Nebraska	3,785,503	923	.0	16.8	16.8
New Hampshire	161,845	53	.0	1.8	1.8
New Mexico	21,973,439	5,744	16.0	119.8	135.8
Nevada	6,320,236	1,834	9.2	31.6	40.8
New York	962,147	165	.0	7.0	7.0
North Dakota	57,779,387	14,220	26.0	241.5	267.5
Ohio	1,042,000	389	.0	7.7	7.7
Oklahoma	72,004,190	14,744	57.0	244.1	301.1
Oregon	4,921,691	1,633	3.0	23.5	26.5
Pennsylvania	7,889,646	2,546	.0	48.5	48.5
South Dakota	611,512	142	1.0	1.9	2.9
Tennessee	4,950,847	1,194	.0	33.5	33.5
Texas	320,103,644	68,241	427.6	1,317.8	1,745.4
Utah	27,850,243	4,661	35.4	87.0	122.4
Virginia	5,597,808	1,803	.0	30.8	30.8
Washington	1,330,000	379	4.0	1.2	5.2
West Virginia	4,939,475	997	.0	23.4	23.4
Wyoming	73,747,389	14,021	42.8	273.8	316.6
Total Land	1,138,539,470	256,201	932.2	4,489.1	5,421.3
Marine					
Undesignated	51,050,841	87,898	18.0	68.9	86.9
Off Alaska	28,599,966	45,767	11.0	62.0	73.0
East Coast	17,513,506	28,115	5.0	35.0	40.0
Gulf Coast	97,470,070	155,397	51.4	171.3	222.7
West Coast	10,505,442	21,024	20.7	12.7	33.4
Total Marine	205,139,825	338,201	106.1	349.9	456.0
Total U.S.A.	1,343,679,295	594,402	1,038.3	4,839.0	5,877.3

*Total includes government and university activity.

Table 9. Petroleum seismic activity in Canada.

Province	Acquisition costs (US$)	Line-miles	Crew-months Company	Crew-months Contract	Total months
Land					
Undesignated	23,164,700	6,867	.0	100.6	100.6
Alberta	98,614,009	24,296	25.0	259.6	284.6
British Columbia	19,161,928	3,787	6.0	43.1	49.1
Manitoba	371,440	105	.0	3.3	3.3
New Brunswick	1,841,000	496	6.0	1.0	7.0
Northwest Territories	5,161,703	889	.0	15.2	15.2
Ontario	900,000	300	.0	8.0	8.0
Quebec	37,000	5	.0	.1	.1
Saskatchewan	8,166,020	3,433	10.0	26.5	36.5
Total land	157,417,800	40,178	47.0	457.4	504.4
Marine					
Undesignated	52,972,000	88,588	.0	72.5	72.5
East Coast	3,301,036	5,100	.0	6.6	6.6
Total Marine	56,273,036	93,688	.0	79.1	79.1
Total Canada	213,690,836	133,866	47.0	536.5	583.5

Table 10. Petroleum seismic activity in Mexico.

Area	Acquisition costs (US$)	Line-miles	Crew-months Company	Crew-months Contract	Total months
Land					
Various	88,226,079	30,837	.0	364.8	364.8
Marine					
Various	8,411,000	29,581	.0	15.0	15.0
Total Mexico	96,637,079	60,418	.0	379.8	379.8

Table 11. Total worldwide expenditures on gravity and magnetic surveys in US$ (thousands).

Area	Petroleum	Minerals	Engineering	Geothermal	Oceanography	Research	Total
International					500	1,236	1,736
U.S.A.	15,816	841	1,635	659		1,267	20,218
Canada	550	1,665	25			237	2,477
Mexico		2,016					2,016
South America	4,317	400				95	4,812
Europe	966	382	9				1,357
Africa	6,711	5,844	76			7	12,638
Middle East	1,322	237					1,559
Far East	705	400	15		607		1,727
Australia/ New Zealand	3	7,704				27	7,734
Total	30,391	19,491	1,760	659	1,107	2,870	56,278

Table 12. Total worldwide expenditures on airborne surveys in US$ (thousands).

Area	Petroleum	Minerals	Geothermal	Oceanography	Research	Total
International				500		500
U.S.A.	7,937	2,557	190			10,684
Canada		12,498				12,498
Mexico		2,152				2,152
South America	4,239	400				4,639
Europe	291	314				605
Africa	2,291	12,672				14,963
Middle East	1,289	1,000				2,289
Far East	1,038	576	5,528	607		7,749
Australia/ New Zealand		10,953			974	11,927
Total	17,085	43,122	5,718	1,107	974	68,006

Table 13A. Western hemisphere airborne activity in US$ (thousands).

	International		USA		Canada		Mexico		South America	
Survey Method	Line-miles	Cost	Line-miles	Cost	Line-miles	Cost	Line-miles	Cost	Line-miles	Cost
Magnetic	50,000	500	414,093	7,224	46,368	850	92,900	2,016	229,545	4,639
Electromagnetic					100,000	3,500				
Combined Em/Mag.			19,200	1,254	52,919	3,172				
VLF					10,825	410				
Input			12,750	583	88,690	3,890	2,550	136		
Radiometric (gamma ray)			450	35	20,586	674				
R-S side-scan radar			208,350§	1,538						
Other			500	50						
Total	50,000	500	655,343	10,684	319,388	12,498	95,450	2,152	229,545	4,639

§Square miles.

Table 13B. Eastern hemisphere airborne activity in US$ (thousands).

	Europe		Africa		Middle East		Far East		Australia	
Survey Method	Line-miles	Cost	Line-miles	Cost	Line-miles	Cost	Line-miles	Cost	Line-miles	Cost
Magnetic	26,745	605	413,461	7,860	41,027	1,526	103,982	1,687	412,227	7,072
Combined Em/Mag.			18,360	1,192	10,000	725			24,470	1,752
Input			4,460	310						
Radiometric (gamma ray)			68,006	2,775	1,532	38	1,250	30	272,511	3,103
R-S side scan radar			103,275§	2,826			205,230§	6,032		
Total	26,745	605	515,762	14,963	52,559	2,290	310,462	7,750	709,208	11,928

§Square miles.

Table 14A. Western Hemisphere land mining activity in US$ (thousands).

Survey method	USA		Canada		South America	
	Line-miles	Cost	Line-miles	Cost	Line-miles	Cost
Dynamite	76	714			223	1,065
Dynamite (refraction)	19	187	80	154		
Weight drop (refraction)	5	3				
Gravity	382	105	268	256		
Magnetic	375	50	3,798	557		
Resistivity	16	36	34	12	97	35
Self-potential	648	122				
Electromagnetic	768	559	3,884	1,187	72	25
Combined Em/Mag.	273	171	1,157	349		
VLF	15	10	464	77		
Afmag			4	3		
Induced polarization	261	425	1,202	1,284	70	62
Radiometric (gamma ray)	20	4	664	62	100	28
Radiometric (alpha track)			462	201		
Magnetotelluric	36	152				
Other	31	60	744	171		
Total	2,925	2,654	12,761	4,320	562	1,215

Table 14B. Eastern Hemisphere land mining activity in US$ (thousands).

Survey method	Europe		Africa		Middle East		Far East		Australia	
	Line-miles	Cost	Line-miles	Cost	Line-miles	Cost	Line-miles	Cost	Line-miles	Cost
Seismic dynamite	676	6,873								
Seismic vibratory	106	404								
Seismic other									15	70
Seismic dynamite (refraction)									5	3
Gravity	245	70	401	77			150	25	2,800	653
Magnetic			2,734	181					400	6
Resistivity	625	234	230	38	150	52				
Self-potential			481	7						
Electromagnetic			967	254					2,000	855
VLF							19	1		
Induced polarization	100	75	516	566			52	45	595	562
Radiometric (gamma ray)			1,500	21			44	12		
Magnetotelluric							1	5		
Other			25	20					150	100
Total	1,752	7,656	6,854	1,164	150	52	266	88	5,965	2,249

Table 15. Worldwide groundwater and engineering activity.

Survey method	Area			Time		Cost
	Line-miles	Stations	Footage	Crew-months	Man-months	US$ (thousands)
Seismic reflection	9,832.0			61.8		6,598.3
Seismic reflection		465.0		5.0		50.0
Seismic refraction	2,791.0			20.8		1,907.6
Seismic refraction	341.0				62.8	327.7
Gravity	1,002.0			15.0		1,501.8
Magnetics	390.0			1.0		144.0
Magnetics	345.0				5.8	100.0
Magnetotellurics	20.0			.2		35.0
Resistivity	6,297.0			147.1		3,336.6
Resistivity	290.0				23.5	277.5
Self-potential	44.0			1.3		69.0
Electromagnetic	335.0				9.6	167.0
VLF	57.0			5.2		30.0
Cross-hole seismic		10		2.5		111.0
Elec. field-Elec. phase	2,260.0			9.0		275.0
Remote sensing	4.0			.2		55.2
Drill hole logging			207,688.0		71.5	598.3
Drill hole logging			41,105.0	30.9		410.0
Other				50.0		1,651.0
Total	24,008.0	475.0	248,793.0	350.0	173.2	17,645.0

Table 16. Worldwide geothermal activity.

Survey method	Area			Time		Cost
	Line-miles	Stations	Footage	Crew-months	Man-months	US$ (thousands)
Seismic reflection	11.0			2.0		591.0
Gravity	148.0			1.6		39.0
Gravity		950.0		2.0		55.0
Magnetics	15,000.0			22.0		565.8
Magnetotellurics	440.0			21.2		2,100.0
Magnetotellurics		204.0			10.6	261.2
Resistivity	111.0			5.2		291.0
Self-potential	501.0			6.8		142.0
Drill hole logging				5.0		470.5
Remote sensing (side-scan radar)	198,000.0§			3.0		5,528.0
Drill hole temp. grad.			300,000.0	64.0		3,175.5
Other				5.7		455.0
Total	16,211.0 198,000.0§	1,154.0	300,000.0	133.5	10.6	13,674.0

§Square miles.

Table 17. Worldwide average unit costs by survey objective, type, and method.

Survey objective, type, and method	Total crew-months* or (man-months)	Line-miles or (logged footage) or [no. of stations]	Acquisition costs (US$)	Average coverage/month or (man-months)	Average cost/month or (man-months)	Average cost/mile or (cost/foot) or [no. of stations]
Petroleum						
Land						
Seismic (P-wave)						
Dynamite	5,158.3	254,745	1,333,010,875	49	258,420	5,232
Compressed air	111.4	20,354	34,982,988	182	314,030	1,718
Gas exploder	75.6	3,404	12,796,355	45	169,263	3,759
Weight drop	160.1	15,477	38,030,556	96	237,542	2,457
Solid chemical	87.0	9,400	38,420,000	108	441,609	4,087
Vibratory	3,674.3	224,565	844,096,234	61	229,729	3,758
Other	65.2	2,072	11,237,526	31	172,354	5,423
Seismic (S-wave)						
Dynamite	183.2	9,388	41,500,000	51	226,528	4,420
Compressed air	12.0	382	1,300,000	31	108,333	3,403
Vibratory	50.0	3,111	12,168,371	62	243,367	3,911
Seismic (refraction)						
Dynamite	3.5	186	1,395,000	53	398,571	7,500
Vibratory	0.3	3	71,400	10	238,000	23,800
Other	14.0	24	2,007,046	1	143,360	83,626
Gravity	228.0	56,357	7,462,000	247	32,728	132
Gravity	63.3	[23,719]	6,608,578	[375]	104,400	[279]
Resistivity	1.0	15	10,000	15	10,000	666
Self-potential	(2.0)	5	45,500	(3)	(22,750)	9,100
Induced polarization	60.4	2,160	3,895,728	35	64,498	1,803
Remote sensing other	0.5	50	264,000	100	528,000	5,280
Magnetotelluric	12.0	66	568,000	5	47,333	8,606
Magnetotelluric	8.9	[354]	955,800	[40]	107,393	[2,700]
Marine						
Seismic (P-wave)						
Compressed air	701.1	664,232	418,523,218	947	596,952	630
Electrical	7.2	7,800	2,260,000	1,083	313,888	289
Gas exploder	282.7	199,693	114,389,675	706	404,632	572
Implosive	99.6	64,920	42,159,850	651	423,291	649
Solid chemical	32.0	25,600	14,080,000	800	440,000	550
Other	12.0	25,159	5,705,000	2,096	475,416	226
Seismic (refraction)						
Compressed air	0.5	15	144,000	30	288,000	9,600
Gravity	34.8	43,733	1,032,050	1,256	29,656	23
Magnetic	3.1	3,800	75,002	1,225	24,194	19
Airborne						
Magnetic	108.5	725,391	15,214,330	6,685	140,224	20
R-S side-scan radar	2.3	210,950§	1,871,400	91,717	813,652	8
Drill hole						
Sonic/velocity logging	(52.9)	**	383,525	**	(7,250)	**

*Total includes government and university activity. **Not applicable. §Square miles

Table 17. Worldwide average unit costs by survey objective, type, and method, cont.

Survey objective, type, and method	Total crew-months* or (man-months)	Line-miles or (logged footage) or [no. of stations]	Acquisition costs (US$)	Average coverage/month or (man-months)	Average cost/month or (man-months)	Average cost/mile or (cost/foot) or [no. of stations]
Minerals						
Land						
Seismic (P-wave)						
Dynamite	45.3	975	8,652,863	21	191,012	8,874
Vibratory	4.1	106	404,000	25	98,536	3,811
Other	1.0	15	70,000	15	70,000	4,666
Seismic (refraction)						
Dynamite	6.5	36	306,700	5	47,184	8,519
Dynamite	(8.0)	68	38,500	(9)	(4,812)	566
Weight drop	0.2	5	3,000	25	15,000	600
Gravity	25.9	1,019	527,400	39	20,362	517
Gravity	(15.9)	407	80,600	(26)	(5,069)	198
Gravity	9.5	[11,000]	375,000	[1,158]	39,474	[34]
Gravity	(33.5)	[20,340]	255,800	(607)	(7,636)	[13]
Magnetic	57.5	2,767	407,796	48	7,092	147
Magnetic	(62.6)	4,270	389,050	(68)	(6,215)	91
Resistivity	24.4	1,073	350,975	43	14,384	327
Resistivity	(28.2)	79	58,100	(3)	(2,060)	735
Self-potential	11.1	1,129	119,900	101	10,801	106
Self-potential	3.0	[1,500]	10,000	[500]	3,333	[7]
Electromagnetic	105.8	4,575	1,891,828	43	17,881	413
Electromagnetic	(89.0)	2,026	562,460	(23)	(6,320)	278
Electromagnetic	(26.0)	[3,670]	427,000	(141)	(16,423)	[116]
Combined Em/Mag.	42.5	1,305	447,200	30	10,522	342
Combined Em/Mag.	(12.5)	125	74,500	(10)	(5,960)	596
VLF	4.8	221	21,995	46	4,582	99
VLF	(8.0)	290	67,500	(36)	(8,438)	233
Afmag	0.2	4	3,000	20	15,000	750
Induced polarization	128.7	2,325	2,603,333	18	20,227	1,119
Induced polarization	(121.0)	471	418,595	(4)	(3,459)	888
Radiometric (gamma ray)	13.0	2,200	99,000	169	7,615	45
Radiometric (alpha track)	4.5	462	201,000	102	44,666	435
Radiometric (alpha track)	(14)	144	28,800	(10)	(2,057)	200
Magnetotelluric	4.4	37	158,167	8	35,947	4,274
Other	15.7	950	352,100	60	22,425	370
Airborne						
Magnetic	134.9	945,067	17,032,720	7,005	126,261	18
Magnetic	(10.2)	35,690	407,000	(3,499)	(39,902)	11
Electromagnetic	36.0	100,000	3,500,000	2,777	97,222	35
Combined Em/Mag.	46.4	115,939	7,647,030	2,498	164,806	65
Combined Em/Mag.	(28.8)	9,010	450,500	(313)	(15,642)	50
VLF	2.3	6,135	399,350	2,667	173,630	65
Input	22.2	108,450	4,919,000	4,885	221,576	45
Radiometric (gamma ray)	59.2	245,195	5,554,017	4,141	93,817	22
Radiometric (gamma ray)	(7.4)	5,140	155,000	(695)	(20,946)	30
R-S side-scan radar	1.6	107,905§	2,997,450	67,440	1,873,406	186
Other	1.0	500	50,000	500	50,000	100

*Total includes government and university activity. §Square miles

Table 17. Worldwide average unit costs by survey objective, type, and method, cont.

Survey objective, type, and method	Total crew-months* or (man-months)	Line-miles or (logged footage) or [no. of stations]	Acquisition costs (US$)	Average coverage/month or (man-months)	Average cost/month or (man-months)	Average cost/mile or (cost/foot) or [no. of stations]
Minerals, cont.						
Drill Hole						
Resistivity	(75.0)	(664,570)	725,000	(8,861)	(9,667)	(1.09)
Electromagnetic	2.2	0	51,800	0	23,545	0
Sonic/velocity logging	15.0	(84,300)	194,300	(5,620)	12,953	(2.30)
Induced polarization	2.7	0	99,600	0	36,888	0
Induced polarization	(30.3)	(278,000)	174,000	(9,175)	(5,743)	(.63)
Radiometric (gamma ray)	1.4	0	43,000	0	30,714	0
Radiometric (gamma ray)	50.0	(231,910)	435,000	(4,638)	8,700	(1.88)
Radiometric (alpha track)	37.0	0	869,965	0	23,512	0
Other	40.0	(98,000)	331,000	(2,450)	8,275	(3.38)
Engineering						
Land						
Seismic (P-wave)						
Dynamite	8.5	82	455,300	9	53,564	5,552
Vibratory	1.3	33	129,000	25	99,230	3,909
Other	(18.0)	15	135,000	(1)	(7,500)	9,000
Seismic (refraction)						
Dynamite	5.0	63	230,600	13	46,120	3,660
Compressed air	2.0	800	200,000	400	100,000	250
Weight drop	(50.0)	265	213,934	(5)	(4,279)	807
Solid chemical	0.5	1	35,000	2	70,000	35,000
Other	(2.5)	10	30,000	(4)	(12,000)	3,000
Gravity	15.0	1,002	1,501,800	66	100,120	1,498
Magnetic	(5.8)	345	100,000	(59)	(17,241)	290
Resistivity	10.9	256	218,000	23	20,000	851
Resistivity	(11.5)	190	127,000	(17)	(11,043)	668
Self-potential	1.1	34	53,000	30	48,181	1,558
Electromagnetic	(5.6)	170	85,000	(30)	(15,179)	500
VLF	5.2	57	30,000	10	5,769	526
Cross-hole seismic	2.5	[10]	111,000	[4]	44,400	[11,100]
Remote sensing other	0.2	4	55,150	20	275,750	13,787
Magnetotelluric	0.2	20	35,000	100	175,000	1,750
Other	26.5	**	720,550	**	27,191	**
Marine						
Seismic (P-wave)						
Electrical	32	5,130	3,820,000	160	119,375	745
Gas exploder	11.0	4,572	2,059,000	415	187,181	450
Seismic (refraction)						
Compressed air	0.8	40	230,000	50	287,500	5,750
Electrical	10.5	1,880	1,122,000	179	106,857	596
Magnetic	1.0	390	144,000	390	144,000	369
Elec. field-Elec. phase	6.0	2,250	270,000	375	45,000	120
Drill hole						
Resistivity	(2.0)	(9,592)	40,000	(4,796)	(20,000)	(4.17)
Self-potential	0.4	(4,592)	20,000	(11,480)	50,000	(4.36)
Sonic/velocity logging	(62.4)	(163,592)	485,200	(2,622)	(7,776)	(2.97)
Radiometric (gamma ray)	(5.5)	(26,000)	51,200	(4,727)	(9,309)	(1.97)
Radiometric (alpha track)	(1.5)	(5,092)	21,200	(3,395)	(14,133)	(4.12)
Other	29.0	**	318,750	**	10,991	**

*Total includes government and university activity. **Not applicable.

Table 17. Worldwide average unit costs by survey objective, type, and method, cont.

Survey objective, type, and method	Total crew-months* or (man-months)	Line-miles or (logged footage) or [no. of stations]	Acquisition costs (US$)	Average coverage/month or (man-months)	Average cost/month or (man-months)	Average cost/mile or (cost/foot) or [no. of stations]
Geothermal						
Land						
Seismic (P-wave)						
Dynamite	2.0	11	591,000	5	295,500	53,727
Gravity	1.6	148	39,000	92	24,375	263
Gravity	2.0	[950]	55,000	[475]	27,500	[58]
Magnetic	20.0	2,000	375,831	100	18,791	187
Resistivity	5.2	111	291,000	21	55,961	2,621
Self-potential	6.8	501	142,000	73	20,882	283
Magnetotelluric	21.2	440	2,100,000	20	99,056	4,772
Magnetotelluric	(10.6)	[204]	261,200	[19]	(24,642)	[1,280]
Other	5.7	**	455,000	**	79,825	**
Airborne						
Magnetic	2.0	13,000	190,000	6,500	95,000	15
R-S side-scan radar	3.0	198,000§	5,528,000	66,000	1,842,666	27
Drill hole						
Temperature gradient	64.0	(300,000)	3,175,475	(4,688)	49,617	(10.60)
Other	5.0	**	470,500	**	94,100	**
Groundwater						
Land						
Seismic (P-wave)						
Weight drop	5.0	[465]	50,000	[93]	10,000	[108]
Seismic (refraction)						
Dynamite	2.0	7	90,000	3	45,000	12,857
Dynamite	(2.0)	18	9,000	(9)	(4,500)	500
Weight drop	(4.5)	28	82,000	(6)	(18,222)	2,928
Solid chemical	(6.3)	30	22,750	(5)	(3,611)	758
Resistivity	136.2	6,041	3,118,612	44	22,897	516
Resistivity	(12.0)	100	150,500	(8)	(12,542)	1,505
Self-potential	0.2	10	16,000	50	80,000	1,600
Electromagnetic	(4.0)	165	82,000	(41)	(20,500)	497
Elec. field-Elec. phase	3.0	10	5,000	3	1,666	500
Other	10	**	875,000	**	87,500	**
Drill hole						
Resistivity	0.5	(9,750)	470,500	(19,500)	6,000	(.31)
Sonic/velocity logging	(0.1)	(3,412)	671	(34,120)	(6,710)	(.20)
Radiometric (gamma ray)	1.0	(26,763)	35,081	(26,763)	35,081	(1.31)
Other	(3.6)	**	33,300	**	(9,250)	**
Oceanography						
Marine						
Seismic (P-wave)						
Compressed air	4.4	6,156	1,397,000	1,399	317,500	226
Electrical	7.2	13,574	1,860,000	1,885	258,333	137
Implosive	18.6	18,003	1,791,000	967	96,290	99
Seismic (refraction)						
Compressed air	0.7	225	139,500	321	199,285	620

*Total includes government and university activity. **Not applicable. §Square miles.

Table 17. Worldwide average unit costs by survey objective, type, and method, cont.

Survey objective, type, and method	Total crew-months* or (man-months)	Line-miles or (logged footage) or [no. of stations]	Acquisition costs (US$)	Average coverage/month or (man-months)	Average cost/month or (man-months)	Average cost/mile or (cost/foot) or [no. of stations]
Oceanography (cont.)						
Airborne						
Magnetic	6.0	110,800	1,107,000	18,466	184,500	9
Research						
Land						
Seismic (P-wave)						
Dynamite	9.0	265	1,220,000	29	135,555	4,603
Weight drop	(.5)	1	25,000	(2)	(50,000)	25,000
Vibratory	1.0	4	200,000	4	200,000	50,000
Other	20.0	**	55,000	**	(2,750)	**
Seismic (S-wave)						
Vibratory	8.3	178	1,217,405	21	146,675	6,839
Seismic (refraction)						
Dynamite	6.2	2,233	512,000	360	82,580	229
Weight drop	0.3	1	1,955	3	6,516	1,955
Gravity	17.5	602	297,600	34	17,005	494
Gravity	55.0	[17,130]	1,254,100	[311]	22,802	[73]
Magnetic	0.3	57	51,900	190	173,000	910
Resistivity	5.0	6	12,000	1	2,400	2,000
Self-potential	1.5	2	48,000	1	32,000	24,000
Electromagnetic	1.5	40	80,000	27	53,333	2,000
Induced polarization	3.0	40	85,280	13	28,426	2,132
Radiometric (gamma ray)	(2.0)	[8]	20,000	[4]	(10,000)	[2,500]
Magnetotelluric	13.0	64.0	124,800	5	9,600	1,950
Other	3.0	125	1,000	41	333	8
Marine						
Seismic (P-wave)						
Compressed air	6.7	16,829	1,085,100	2,511	161,955	64
Electrical	1.5	1,400	60,000	933	40,000	42
Seismic (refraction)						
Dynamite	2.0	900	430,900	450	215,450	478
Compressed air	2.0	300	20,000	150	10,000	66
Magnetic	8.4	40,014	1,236,000	4,763	147,142	30
Other	1.0	5,000	100,000	5,000	100,000	20
Airborne						
Magnetic	1.0	400	27,500	400	27,500	68
Radiometric (gamma ray)	11.5	114,000	947,000	9,913	82,347	8
Drill hole						
Resistivity	6.5	**	40,000	**	6,154	**
Sonic/velocity logging	2.0	**	10,000	**	5,000	**
Electromagnetic	1.8	**	34,100	**	18,944	**
Radiometric (gamma ray)	8.0	**	40,000	**	5,000	**
Temperature gradient	2.0	**	10,000	**	5,000	**
Other	12.0	**	60,000	**	5,000	**

*Total includes government and university activity. **Not applicable.

(Continued from p. 8)

Airborne surveys

Statistical data on airborne surveys are shown in Tables 12, 13a, and 13b. Airborne activity increased 45 percent with most of the increase coming in the mining area. There was also a significant increase of airborne work in geothermal and oceanography. Magnetic surveys continue to be the most popular with remote-sensing ranked second. Combined EM/Mag surveys showed the largest percent increase over 1980 and rank third in total expenditures spent in 1981.

Land mining

Tables 14a and 14b report expenditures and methods used for land mining in the Western and Eastern Hemispheres. Reported usage of geophysical exploration for minerals using land methods was down worldwide, but up slightly in Canada and South America. We suspect that land mining activity is still somewhat under-reproted.

Engineering, geothermal, groundwater, oceanography, and research

Table 15 reports engineering/groundwater activity. Table 16 contains worldwide geothermal work. Average unit costs for all survey objectives, types, and methods can be found in Table 17. Groundwater activity is about level with last year, and engineering is down slightly. The large number of dollars in the other category (see Table 15) were spent in Algeria doing survey foundation studies. Geothermal activity is up 116 percent with most of this increase from the remote-sensing airborne work flown in the Far East. Research has declined, but oceanography is up 14 percent.

Summary

In general, the data reported here are believed to be more complete than in 1980 due to better response to the questionnaires. As companies and contractors become convinced that the confidential and financially sensitive data requested on the questionnaires are being properly safeguarded and protected, we believe that more complete data will become available.

Acknowledgments

This report was made possible through the contributions of statistical data by companies, contractors, government agencies, and universities. For many of these organizations, compilation of these data was a long and tedious task. The Geophysical Activity Committee expresses sincere appreciation to all of those individuals who were instrumental in preparing and submitting their activity questionnaires. The committee welcomes comments and suggestions on ways to improve this report.

A special vote of thanks goes to Jerry Henry and Tricia Auberle of the SEG Business Office who handled the voluminous chores of mailing, receiving, coding, and checking the questionnaires. I would also like to thank Bob Austin and H. T. Konkler for the long hours they worked with the computer generating the tables for this report.

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SEG

Special Report

Geophysical Activity in 1982

Compiled by the

Geophysical Activity Committee

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Special Report
Geophysical Activity in 1982

Russell J. Senti*

Report of the SEG Geophysical Activity Committee. Members of the Committee are Russell J. Senti, Chairman; Lionel G. Cane, Charles E. Curtis, Harry R. Espey, Lin Evans, Ronald R. Hartman, Richard Hopkins, William C. Kellogg, Fritz P. Kronberger, James R. McBeth, Gerald E. Montgomery, H. Roice Nelson, Jr., Paul L. Stoffa, Tommy A. Tillery, A. H. Watts, and Don Watts.

Introduction

This report presents statistical data on worldwide geophysical activity in 1982. The data were gathered from survey questionnaires that were mailed to more than 600 companies, contractors, government agencies, and institutions throughout the free world. We have attempted to gather data from all users of geophysical techniques in the areas of petroleum, mining, geothermal, and groundwater exploration and from those who employ geophysical methods in engineering, oceanography, and research. Response to the survey was excellent, thanks to a computerized mailing list that was implemented at the SEG Business Office this year. There was almost a 30 percent increase in the amount of data received this year compared to the amount received last year. In 1981 there was a major transition from rapid growth in the early part of the year to a sharp decline toward the end of the year. This circumstance generated an additional degree of uncertainty in evaluating the completeness of the response.

Detailed information was gathered on airborne, drill hole, land, and marine geophysical surveys. Statistics were compiled on miles of coverage, number of stations, drill hole footage, time spent in crew-months or man-months, and acquisition costs. Data not supplied on the questionnaires by the respondent were estimated on the basis of massive statistical averaging for the area and techniques reported. This process is necessary to avoid distortion of individual statistical items.

This report, when compared to past annual reports, provides a basis for detecting and analyzing trends in technological developments and exploratory trends in geographical areas. However, owing both to the improved response to the survey in 1982 and to the unusual and rapidly changing level of activity in 1981, the activity in 1981 is probably understated relative to 1982, and one should exercise caution in drawing conclusions from the year to year comparisons. The trends from year to year are not affected just by the amount of data we receive each year. Changes in these trends can be influenced by many other factors, such as technologi-

Table 1. Total worldwide expenditures in US$ (thousands) by survey type and objective.

Type	Petroleum[1]	Minerals	Engineering	Geothermal	Groundwater	Oceanography	Research	Total
Land	2,596,146	17,707	4,245	4,215	2,339	45	9,556	2,634,253
Marine	1,443,668	630	19,396		3	9,131	4,909	1,477,737
Airborne	22,174	19,551	208	6,497			1,382	49,812
Drill hole	4,152	1,117	343	222	134		108	6,076
Total	4,066,140	39,005	24,192	10,934	2,476	9,176	15,955	4,167,878

[1]Includes processing and interpretation costs for land and marine. See text for details.

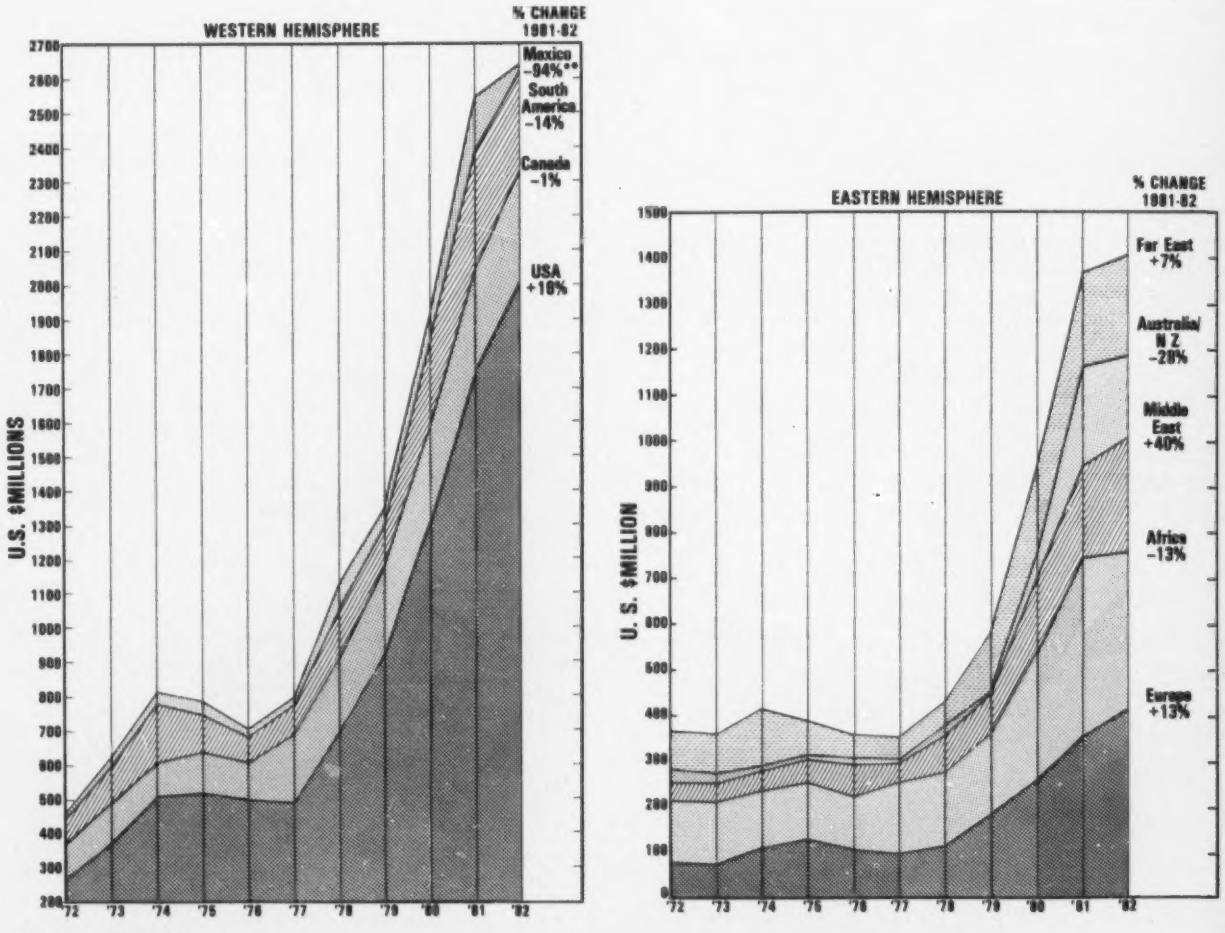
Note: All tables in this report where figures are expressed in thousands of dollars have been rounded off as individual items; but the computer keeps track of all the truncated numbers and then the sums of the individual items are rounded off. As a result of this procedure, the rounded individual items may not add up precisely to the rounded sums.

*Texaco Inc., P.O. Box 2420, Tulsa, OK 74102.

Table 2. Total worldwide expenditures in US$ (thousands) by area and survey objective.

Area	Petroleum[1]	Minerals	Engineering	Geothermal	Groundwater	Oceanography	Research	Total
International	19,198					2,284	2,981	24,463
U.S.A.	2,033,841	5,309	12,217	2,708	536	2,498	11,243	2,068,352
Canada	297,748	9,336	1,333		133	45	668	309,263
Mexico**	7,664	658	10				40	8,372
South America	305,202	1,520	520		100	1,500	300	309,142
Europe	412,221	7,853	5,588	66	240		162	426,130
Africa	339,366	6,769	2,084		1,027	444	547	350,237
Middle East	277,893	575	1,038		400			279,906
Far East	217,710	782	1,400	8,160		2,405		230,457
Australia/ New Zealand	155,297	6,203	2		40		14	161,556
Total	4,066,140	39,005	24,192	10,934	2,476	9,176	15,955	4,167,878

[1]Includes processing and interpretation costs. **Incomplete data.



**Incomplete data

FIG. 1 Total expenditures on petroleum exploration, 1972-1982.
(Data are believed to be under-reported for 1981 in both hemispheres.)

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Table 3. Worldwide petroleum land seismic activity.

Area	Acquisition costs (US$)	Line-miles	Crew-months*		Crew-months total*	Average mile/month	Average cost/month	Average cost/mile
			Company	Contract				
U.S.A.	1,114,289,943	248,483	581.5	4,516.6	5,098.1	48	218,569	4,484
Canada	166,607,259	44,085	52.0	411.1	463.1	95	359,765	3,779
Mexico**	5,298,636	2,740		94.3	94.3	29	56,189	1,933
South America	191,562,058	39,927	28.8	618.1	646.9	61	296,123	4,797
Europe	116,126,399	30,759		568.3	568.3	54	204,339	3,775
Africa	203,940,915	56,405	23.5	650.8	674.3	83	302,448	3,615
Middle East	228,780,870	37,058	6.0	450.2	456.2	81	501,492	6,173
Far East	116,566,681	26,939	5.2	400.0	405.2	66	287,676	4,327
Australia/ New Zealand	79,442,006	28,436	2.5	234.4	236.9	120	335,339	2,793
Total	2,222,614,767	514,832	699.5	7,943.8	8,643.3	59	257,148	4,317

*Total includes government and university activity.
**Incomplete data.

Table 4. Worldwide petroleum land seismic line-miles by energy source.

Area	Dynamite	Compressed air	Gas exploder	Weight drop	Solid chemical	Vibrator	Other	Total line-miles
U.S.A.	98,477	43,151	1,752		720	104,341	42	248,483
Canada	36,679	500		702		6,114	90	44,085
Mexico**	717	141				1,882		2,740
South America	17,680				730	21,517		39,927
Europe	13,654			215		16,425	465	30,759
Africa	24,620	1,988		5,748		24,049		56,405
Middle East	8,857	1,538		2,702	1,575	22,386		37,058
Far East	22,062	999			75	3,278	525	26,939
Australia/ New Zealand	11,389			1,185		15,862		28,436
Total	234,135	48,317	1,752	10,552	3,100	215,854	1,122	514,832

**Incomplete data

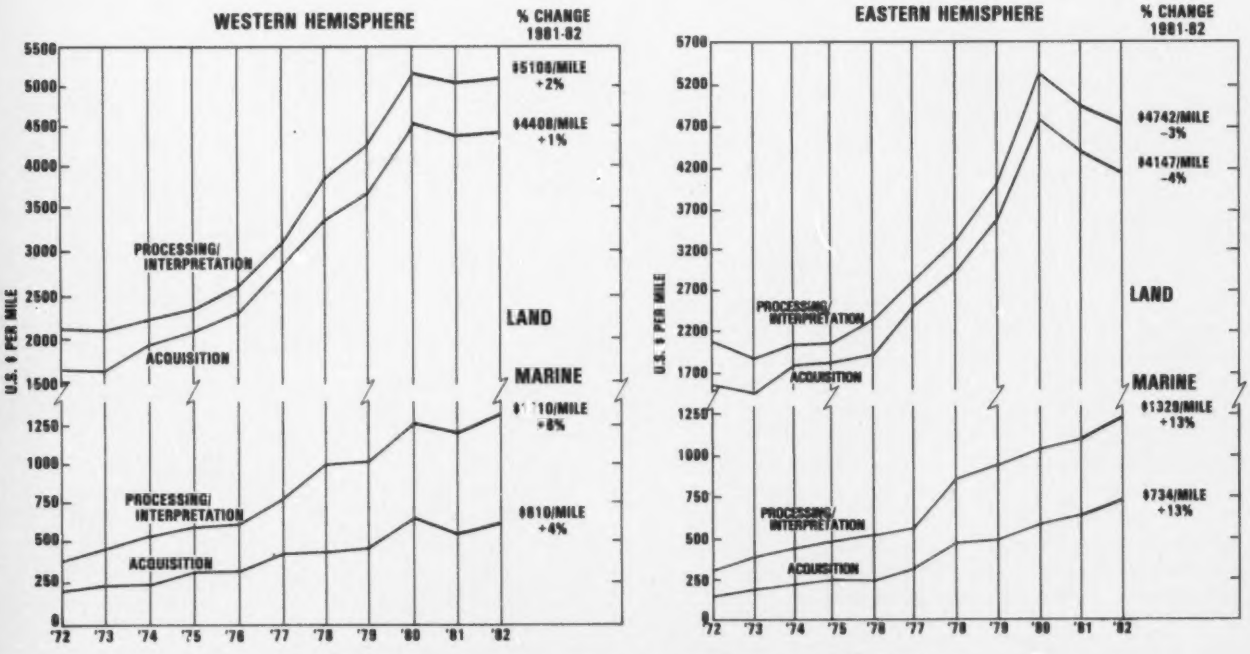

FIG. 2 Average cost per mile for petroleum surveys, 1972-1982.

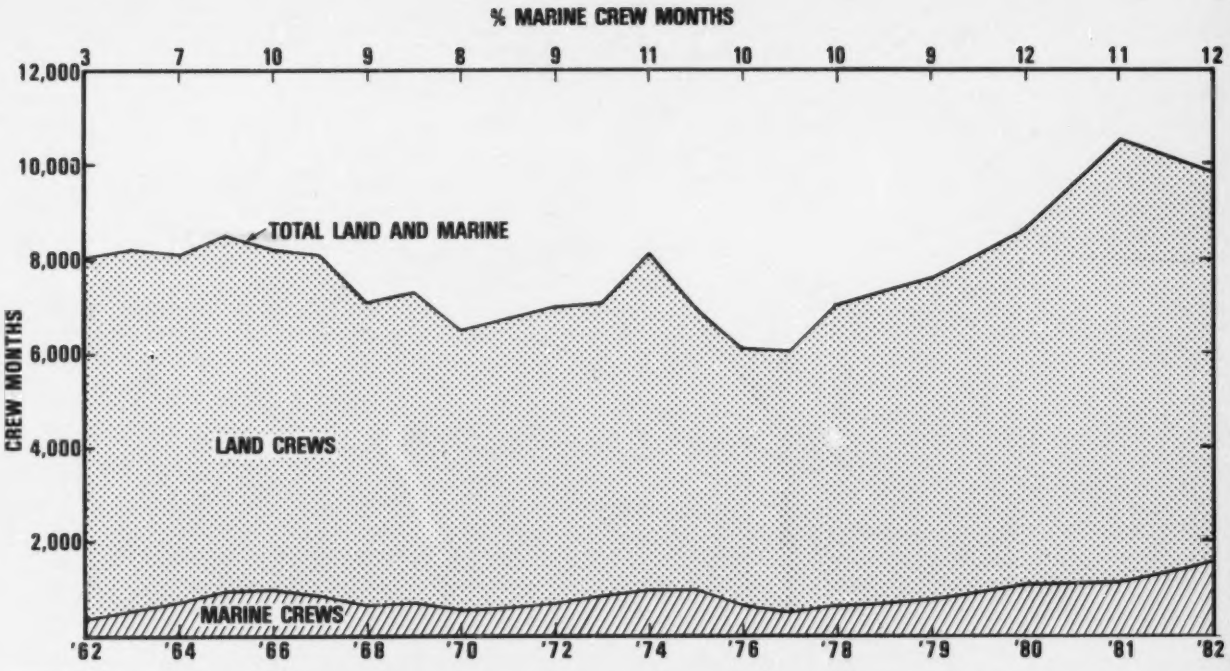

FIG. 3 Worldwide seismic activity in crew-months, 1962-1982.

cal advances, inflation, government regulations, and exploration philosophy. Cost figures are also sensitive to many factors, such as operational environment, length and nature of the survey, type of instrumentation, etc. Unit costs reported by universities are substantially lower than those reported by industry due to the use of student labor and donated equipment. These costs, however, must be averaged with industry costs to accommodate the format of the report. Therefore, when examining unit cost figures, one must be cognizant of the broad spectrum of activity embraced by individual categories.

1982 Highlights

Worldwide expenditures on geophysical exploration in 1982 were approximately level with those reported last year, but were up nearly 40 percent from 1980 (see Table 1). The increase came primarily in the petroleum area. Expenditures reported for engineering, research and oceanography were up 85, 71, and 46 percent, respectively. This reverses a declining trend in these three areas which we believe was due to incomplete information in years past. It appears our problem of under-reporting in these areas has been corrected. Expenditures reported for geothermal, mining, and groundwater were all down some 20-46 percent.

Distribution of expenditures by geographic area and survey objective is shown in Table 2. Approximately 50 percent of all expenditures for geophysical work was spent in the United States. It's not surprising then that the geographic area with the largest increase was the U.S. The area with the largest decrease was Mexico, but we believe that at least half of the drop in expenditures reported was due to incomplete information. The Far East, Europe, and the Middle East had increases of 7, 13, and 41 percent, respectively, while Canada, South America, Africa, and Australia/New Zealand all declined some 3-30 percent.

The cost of processing and interpretation are included in Figures 1 and 2 and the petroleum column of Tables 1 and 2. All other tables show acquisition costs only. Again, this year two additional columns (one for processing costs and one for interpretation costs) were added to our questionnaires. It was hoped we could obtain more detailed data for these costs. Unfortunately, less than 10 percent of the companies and contractors responded. I did use this small bit of data, combined with my own best estimates to arrive at the following figures: US $700 per line-mile was used for the Western Hemisphere and US $595 per line-mile was used for the Eastern Hemisphere. The higher cost in the Western Hemisphere is based on the premise that, in general, a more rigorous processing and interpretation treatment is required because of the subtle structural and stratigraphic prospects that may be economically viable objectives in much of the Western Hemisphere but are not usually primary targets in much of the Eastern Hemisphere.

Petroleum exploration

Almost 98 percent of all geophysical dollars were spent on petroleum exploration in 1982, reaching an all-time record high of U.S. $4 billion. Expenditures in the U.S. increased 16 percent while the Middle East showed a strong increase of 40 percent. Other areas that experienced slight gains include the Far East and Europe. Geophysical activity in the Western Hemisphere rose slightly by approximately 4 percent, while the Eastern Hemisphere rose a little over 2 percent.

A 10-year history of geophysical activity in both the Western and Eastern Hemispheres is shown in Figure 1.

Seismic surveys

The seismic method accounted for over 95 percent of all expenditures in geophysical activity. This statistic, plus the strong tendency for wildcatting to follow and parallel seismic

Table 5. Worldwide petroleum marine seismic activity.

Area	Acquisition costs (US$)	Line-miles	Crew-months*		Crew-months total*	Average mile/month	Average cost/month	Average cost/mile
			Company	Contract				
International	18,850,016	21,248		24.5	24.5	867	769,388	887
U.S.A.	321,893,511	559,614	71.7	506.4	578.1	968	556,812	575
Canada	58,515,938	57,617		64.2	64.2	897	911,463	1,015
Mexico**								
South America	35,237,715	64,480		66.9	66.9	963	526,722	546
Europe	153,300,750	206,029		229.7	229.7	896	667,395	744
Africa	49,874,823	63,345	.1	80.2	80.3	788	621,106	787
Middle East	13,753,000	20,138		24.1	24.1	835	570,563	682
Far East	39,457,290	69,842	1.8	65.7	67.5	1,034	584,552	564
Australia/ New Zealand	35,700,000	38,363	.5	42.3	42.8	896	834,112	930
Total	726,583,043	1,100,676	74.1	1,104.0	1,178.1	934	616,741	660

*Total includes government and university activity.
**Incomplete data.

Table 6. Worldwide petroleum marine seismic line-miles by energy source.

Area	Compressed air	Electrical	Gas exploder	Implosive	Total line-miles
International	20,979			269	21,248
U.S.A.	419,955	1,150	120,600	17,909	559,614
Canada	57,301			316	57,617
Mexico**					
South America	58,369		2,300	3,811	64,480
Europe	186,647		4,000	15,382	206,029
Africa	47,171			16,174	63,345
Middle East	20,138				20,138
Far East	69,842				69,842
Australia/ New Zealand	38,363				38,363
Total	918,765	1,150	126,900	53,861	1,100,676

**Incomplete data

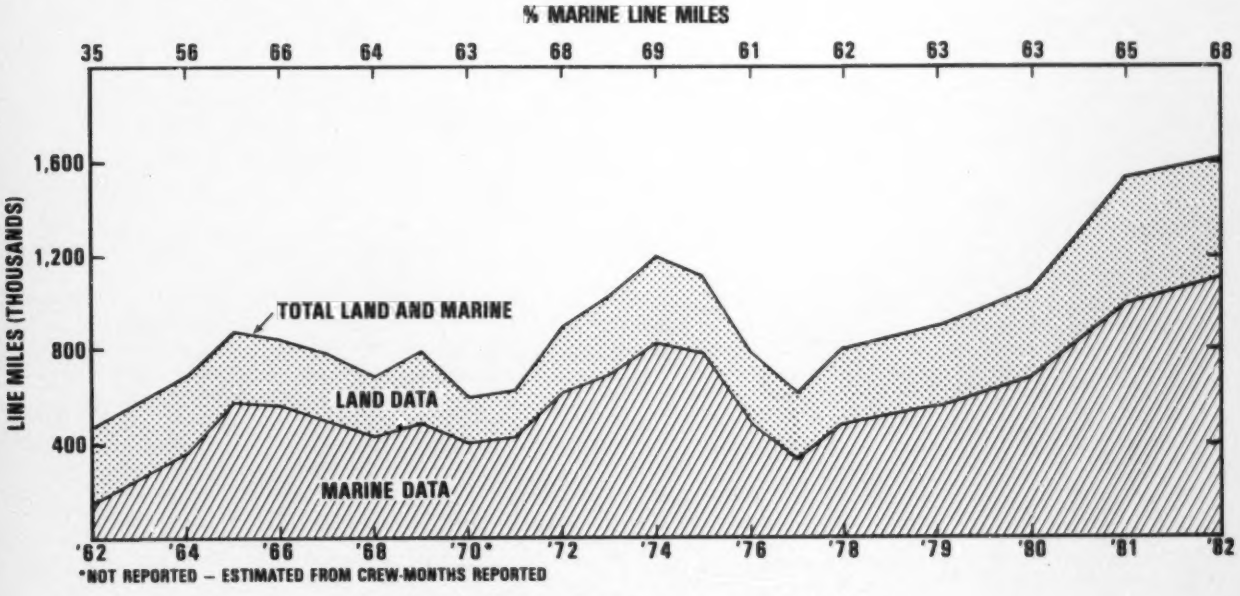
% MARINE LINE MILES
35 56 66 64 63 68 69 61 62 63 63 65 68
LINE MILES (THOUSANDS)
1,600
1,200
800
400
TOTAL LAND AND MARINE
LAND DATA
MARINE DATA
'62 '64 '66 '68 '70* '72 '74 '76 '78 '79 '80 '81 '82
*NOT REPORTED – ESTIMATED FROM CREW-MONTHS REPORTED

FIG. 4 Worldwide seismic activity in line-miles, 1962-1982.

Table 7. Worldwide average unit costs for petroleum surveys.

Area, survey type, and method	Total* crew-months or (man-months)	Line-miles or (logged-footage) or [no. of stations]	Acquisition costs — US$	Avg. miles or (feet.) or [sta.]/month or (man-month)	Average cost/month or (cost/man-month)	Average cost/mile or (foot) or [station]
International						
Marine						
Seismic (P-wave)						
Compressed air	24.1	20,979	18,670,016	870	774,689	889
Implosive	.4	269	180,000	599	400,000	667
Airborne						
Magnetic	1.0	17,444	348,880	17,444	348,880	20
U.S.A.						
Land						
Seismic (P-wave)						
Dynamite	2,633.3	97,491	549,160,797	37	208,543	5,632
Compressed air	247.5	42,244	76,166,180	170	307,667	1,802
Gas exploder	48.0	1,752	9,878,600	36	205,804	5,638
Solid chemical	24.0	720	2,760,000	30	115,000	3,833
Vibratory	2,066.6	103,628	462,573,283	50	223,825	4,463
Other	2.6	42	162,037	15	60,916	3,858
Seismic (S-wave)						
Dynamite	17.0	312	994,427	18	58,495	3,182
Vibratory	29.7	690	8,901,213	23	299,704	12,900
Seismic (refraction)						
Dynamite	28.0	683	2,670,400	24	95,371	3,909
Compressed air	2.5	910	663,281	364	265,312	728
Vibratory	1.0	43	319,725	43	319,725	7,401
Gravity	210.1	47,377	6,865,204	225	32,668	144
Gravity	71.8	[59,710]	1,886,046	[831]	26,268	[31]
Magnetic	32.0	4,923	575,000	153	17,968	116
Magnetic	6.3	[4,707]	58,108	[747]	9,223	[12]
Self potential	3.0	200	50,000	66	16,666	250
Electromagnetic	12.5	937	892,500	75	71,400	952
Induced polarization	32.6	463	1,281,725	14	39,256	2,768
Magnetotelluric	18.5	488	1,105,650	26	59,764	2,262
Magnetotelluric	8.5	[372]	1,233,322	[43]	145,096	[3,315]
Other	17.8	950	3,410,659	53	191,610	3,590
Other	(16.0)	[3,536]	310,000	[221]	(19,375)	[87]
Marine						
Seismic (P-wave)						
Compressed air	433.1	419,955	261,298,511	969	603,210	622
Electrical	(5.0)	1,150	410,000	(230)	(82,000)	356
Gas exploder	115.0	120,600	48,185,000	1,048	419,000	399
Implosive	30.0	17,909	12,000,000	596	400,000	670
Gravity	32.0	32,000	580,000	1,000	18,125	18
Airborne						
Gravity	5.0	[123,000]	3,000,000	[24,600]	600,000	[24]
Magnetic	67.4	379,563	6,837,275	5,627	101,368	18
R-S side-scan radar	1.5	71,400§	2,055	47,600§	1,370,000	29§
Drill hole						
Sonic/velocity logging	1.0	**	90,000	**	90,000	**
Temperature gradient	(1.0)	(300)	20,000	(300)	(20,000)	(66)
Other	(18.0)	(15,000)	1,500,000	(833)	(83,333)	(100)

*Total includes government and university activity.
**Incomplete data.
§Square miles.

Table 7. Worldwide average unit costs for petroleum surveys (cont.).

Area, survey type, and method	Total* crew-months or (man-months)	Line-miles or (logged-footage) or [no. of stations]	Acquisition costs — US$	Avg. miles or (feet.) or [sta.]/month or (man-month)	Average cost/month or (cost/man-month)	Average cost/mile or (foot) or [station]
Canada						
Land						
Seismic (P-wave)						
Dynamite	371.7	36,681	136,371,947	98	366,808	3,717
Compressed air	6.0	500	1,200,000	83	200,000	2,400
Weight drop	7.0	700	1,925,000	100	275,000	2,750
Vibratory	77.2	6,114	26,740,312	79	346,152	4,373
Other	1.2	90	360,000	75	300,000	4,000
Gravity	8.0	3,040	375,000	380	46,875	123
Resistivity	(.5)	5	30,000	(10)	(60,000)	6,000
Induced polarization	1.0	20	69,000	20	69,000	3,450
Other	(2.0)	[8]	50,000	[4]	(25,000)	[6,250]
Marine						
Seismic (P-wave)						
Compressed air	63.7	57,301	58,305,138	899	915,308	1,017
Implosive	.5	316	210,800	596	397,735	666
Airborne						
Magnetic	3.7	65,882	580,100	17,568	154,693	8
Mexico**						
Land						
Seismic (P-wave)						
Dynamite	42.3	717	1,344,636	16	31,788	1,875
Compressed air	4.0	141	541,000	35	135,250	3,836
Vibratory	48.0	1,882	3,413,000	39	71,104	1,813
Electromagnetic	4.5	337	337,500	75	75,000	1,000
Airborne						
Magnetic	1.0	6,500	110,500	6,500	110,500	17
South America						
Land						
Seismic (P-wave)						
Dynamite	324.2	17,380	88,216,986	53	272,106	5,075
Solid chemical	20.5	730	12,162,000	35	593,268	16,660
Vibratory	298.2	21,517	90,303,072	72	302,827	4,196
Seismic (refraction)						
Dynamite	4.0	300	880,000	75	220,000	2,933
Gravity	3.0	600	156,000	200	52,000	260
Magnetic	13.5	1,000	115,000	74	8,518	115
Other	15.0	794	2,426,234	52	161,748	3,055
Marine						
Seismic (P-wave)						
Compressed air	57.6	58,369	31,802,715	1,013	552,130	544
Gas exploder	3.0	2,300	885,000	766	295,000	384
Implosive	6.3	3,811	2,550,000	600	401,574	669
Gravity	2.0	1,500	80,000	750	40,000	53
Airborne						
Magnetic	4.0	14,585	380,000	3,646	95,000	26
R-S side-scan radar	2.0	48,600§	2,160	24,300§	1,080,000	44§

*Total includes government and university activity.
**Incomplete data.
§Square miles.

Table 7. Worldwide average unit costs for petroleum surveys (cont.).

Area, survey type, and method	Total* crew-months or (man-months)	Line-miles or (logged-footage) or [no. of stations]	Acquisition costs — US$	Avg. miles or (feet.) or [sta.]/month or (man-month)	Average cost/month or (cost/man-month)	Average cost/mile or (foot) or [station]
Europe						
Land						
Seismic (P-wave)						
Dynamite	313.7	13,654	68,189,500	43	217,371	4,994
Weight drop	5.9	215	750,000	36	127,118	3,488
Vibratory	242.5	16,425	45,326,899	67	186,915	2,759
Other	6.2	465	1,860,000	75	300,000	4,000
Gravity	22.5	11,946	992,700	530	44,120	83
Resistivity	2.5	37	25,000	15	10,000	666
Electromagnetic	2.5	187	187,500	75	75,000	1,000
Marine						
Seismic (P-wave)						
Compressed air	204.8	186,647	141,248,750	911	689,691	756
Gas exploder	4.0	4,000	1,600,000	1,000	400,000	400
Implosive	21.2	15,387	10,452,000	724	491,858	679
Gravity	5.0	6,250	180,000	1,250	36,000	28
Drill hole						
Sonic/velocity logging	6.5	**	130,000	**	20,000	**
Africa						
Land						
Seismic (P-wave)						
Dynamite	304.0	24,620	87,332,229	80	287,277	3,547
Compressed air	25.0	1,988	10,201,355	79	408,054	5,130
Weight drop	54.2	5,748	14,310,543	106	264,032	2,489
Vibratory	291.1	24,049	92,096,788	82	316,320	3,829
Gravity	9.0	1,855	252,500	206	28,055	136
Magnetic	1.1	226	27,160	205	24,690	119
Other	11.9	1,000	8,780,853	84	737,886	8,780
Marine						
Seismic (P-wave)						
Compressed air	53.5	47,171	38,882,023	881	726,766	824
Implosive	26.9	16,178	10,992,800	600	408,350	679
Airborne						
Magnetic	18.3	132,276	2,890,880	7,196	157,284	21
R-S side-scan radar	1.0	166,785§	1,142,477	166,785§	1,142,477	7§
Middle East						
Land						
Seismic (P-wave)						
Dynamite	101.7	8,857	32,726,831	87	321,797	3,695
Compressed air	17.0	1,538	7,512,000	90	441,882	4,883
Weight drop	19.2	2,702	6,271,716	140	326,651	2,321
Solid chemical	21.0	1,575	6,510,000	75	310,000	4,133
Vibratory	297.3	22,386	175,760,323	75	591,188	7,851
Gravity	44.0	6,963	997,100	158	22,661	143
Marine						
Seismic (P-wave)						
Compressed air	24.1	20,138	13,753,000	835	570,663	682
Airborne						
Magnetic	2.1	15,200	328,400	7,238	156,380	21
Drill hole						
Sonic/velocity logging	.1	**	2,000	**	20,000	**

*Total includes government and university activity.
**Incomplete data.
§Square miles.

Table 7. Worldwide average unit costs for petroleum surveys (cont.).

Area, survey type, and method	Total* crew-months or (man-months)	Line-miles or (logged-footage) or [no. of stations]	Acquisition costs — US$	Avg. miles or (feet.) or [sta.]/month or (man-month)	Average cost/month or (cost/ man-month)	Average cost/mile or (foot) or [station]
Far East						
Land						
Seismic (P-wave)						
Dynamite	359.3	22,062	104,246,948	61	290,139	4,725
Compressed air	5.0	920	1,340,900	184	268,180	1,456
Solid chemical	1.0	75	310,000	75	310,000	4,133
Vibratory	32.7	3,278	8,510,143	100	260,249	2,596
Other	7.0	525	2,100,000	75	300,000	4,000
Seismic (refraction)						
Compressed air	.2	79	58,690	397	293,450	738
Gravity	5.0	920	134,000	184	26,800	145
Magnetic	1.0	30	15,000	30	15,000	500
Electromagnetic	21.5	1,612	1,612,500	75	75,000	1,000
Marine						
Seismic (P-wave)						
Compressed air	67.5	69,842	39,457,290	1,034	584,552	564
Airborne						
R-S side-scan radar	1.9	190,035§	2,339,977	100,018§	1,231,567	12§
Australia/New Zealand						
Land						
Seismic (P-wave)						
Dynamite	102.1	11,385	24,485,003	111	239,813	2,150
Weight drop	10.0	1,185	3,921,216	118	392,121	3,309
Vibratory	124.4	15,862	50,984,687	127	409,844	3,214
Seismic (S-wave)						
Dynamite	.5	7	51,100	14	102,200	7,000
Gravity	8.0	3,900	140,000	487	17,500	35
Gravity	(8.0)	[2,220]	24,000	[277]	(3,000)	[10]
Marine						
Seismic (P-wave)						
Compressed air	42.8	38,364	35,700,000	894	832,750	930
Drill hole						
Sonic/velocity logging	(2.0)	**	60,000	**	(30,000)	**
Radiometric						
Neutron activation	(12.0)	(8,000)	185,000	(666)	(15,416)	(23)

*Total includes government and university activity.
**Incomplete data.
§Square miles.

activity, has caused those interested in forecasts of petroleum exploration to regard seismic activity as the barometer for exploration. A 10-year history of the cost of petroleum seismic surveys in both the Eastern and Western Hemispheres is shown in Figure 2. In the Western Hemisphere, the acquisition cost per mile of land seismic surveys rose 1 percent, while marine costs increased 4 percent. In the Eastern Hemisphere, acquisition costs per mile for land seismic decreased 4 percent, while marine costs rose almost 17 percent.

The total number of miles of seismic data recorded worldwide was down 5 percent on land and up 11 percent in marine work (see Tables 3 and 5). The increase in marine work shouldn't come as any surprise. While we had a reduction of land crews in 1982, we had an accelerated usage of marine crews. The utilization of marine crews in 1982 was greater than in 1981. In other words, there were more marine crews idle during some part of 1981 than in 1982. Group seismic surveys and speculation surveys are still very popular. Operators, reacting to increasing costs of gathering data, choose to sacrifice the competitive advantages of proprietary data for the low cost of nonproprietary data.

The most popular land seismic energy source worldwide is still dynamite, but for the first time ever there were more Vibroseis miles of seismic data gathered in the U.S. than dynamite (see Table 4). Together these two energy sources account for 87 percent of all seismic land work. The compressed air source captured 9 percent of this land work total. In marine work the air gun and gas exploder sources accounted for 95 percent of the total line miles (see Table 6).

A more comprehensive breakdown of statistical data on petroleum surveys, sorted by geographic area, can be seen in Table 7. Table 8 shows petroleum seismic activity by states in the U.S. Some of the states showing large gains over last year

Table 8. U.S.A. petroleum seismic activity by area.

State	Acquisition Costs (US$)	Line-miles	Crew-months*		Total months
			Company	Contract	
Land					
Undesignated	44,175,000	12,353	17.0	176.6	193.6
Alaska	113,893,280	13,822	35.0	94.0	129.0
Alabama	28,732,267	4,583	19.6	96.8	116.4
Arkansas	24,375,714	4,832	6.0	110.8	116.8
Arizona	1,645,024	420	.0	9.1	9.1
California	38,020,755	9,704	36.0	185.3	221.3
Colorado	21,473,938	6,632	11.0	130.1	141.1
Florida	4,745,171	1,213	2.0	17.8	19.8
Georgia	1,978,471	543	.0	10.1	10.1
Idaho	9,493,210	1,382	5.3	23.8	29.1
Illinois	1,848,000	911	.0	16.3	16.3
Indiana	20,000	4	.0	.5	.5
Kansas	16,428,935	4,472	1.0	96.9	97.9
Kentucky	579,000	216	.0	4.0	4.0
Louisiana	136,976,658	25,609	62.0	501.4	563.4
Maryland	283,000	62	.0	1.5	1.5
Michigan	24,587,000	5,528	18.5	140.7	159.2
Mississippi	35,302,162	6,534	40.8	139.3	180.1
Montana	49,150,909	9,621	29.0	195.1	224.1
North Carolina	217,083	48	.0	1.2	1.2
North Dakota	47,324,353	10,533	20.2	231.6	251.8
Nebraska	2,492,167	968	4.5	15.4	19.9
New Mexico	30,107,543	7,752	6.1	150.2	156.3
Nevada	15,598,850	2,684	8.3	52.0	60.3
New York	1,601,000	315	.7	6.7	7.4
Ohio	369,550	83	1.0	1.9	2.9
Oklahoma	55,561,756	11,379	35.2	220.6	255.8
Oregon	5,606,184	1,200	2.0	24.5	26.5
Pennsylvania	6,542,600	1,672	.0	37.0	37.0
South Dakota	1,643,452	511	.0	9.4	9.4
Tennessee	4,759,422	930	.0	23.8	23.8
Texas	300,307,193	84,887	172.5	1,410.9	1,583.4
Utah	24,610,550	5,245	16.0	110.7	126.7
Virginia	3,010,203	665	.0	17.5	17.5
Vermont	900,000	400	.0	10.0	10.0
Washington	3,323,345	428	5.0	8.0	13.0
West Virginia	1,366,569	340	.0	8.8	8.8
Wyoming	55,199,629	10,002	26.8	226.3	253.1
Total Land	1,114,249,943	248,483	581.5	4,516.6	5,098.1
Marine					
Undesignated	12,000,000	17,909	.0	30.0	30.0
East Coast	28,766,867	43,696	11.0	26.2	37.2
Gulf Coast	192,041,644	377,485	60.7	332.2	392.9
Off Alaska	53,173,000	68,658	.0	65.0	65.0
West Coast	35,502,000	50,716	.0	53.0	53.0
Total Marine	321,483,511	558,464	71.7	506.4	578.1
Total U.S.A.	1,435,733,454	806,947	653.2	5,023.0	5,676.2

*Total includes government and university activity.

were Alaska, Arkansas, Colorado, Georgia, Idaho, Nevada, South Dakota, Vermont, and Washington. The states of Arizona, Montana, and West Virginia showed a significant reduction in activity in 1982. Tables 9 and 10 show petroleum seismic activity in Canada and Mexico, respectively. Again, we believe Mexico is considerably under-reported.

A 50-year history of seismic exploration in the U.S. is shown in Figure 5. This information is compiled by the SEG Business office. Data for this graph are gathered monthly by telephone.

Table 9. Canada petroleum seismic activity by area.

Province	Acquisition Costs (US$)	Line-miles	Crew-months Company	Crew-months Contract	Total months
Land					
Undesignated	9,649,000	2,077	.0	26.9	26.9
Alberta	135,240,525	36,073	33.0	330.6	363.6
British Columbia	6,078,747	1,182	3.0	10.7	13.7
Manitoba	1,375,447	546	.0	5.7	5.7
New Brunswick	1,327,400	321	5.0	.0	5.0
Nova Scotia	70,700	5	.0	.5	.5
Northwest Territories	3,059,475	626	.0	10.2	10.2
Ontario	1,000,000	200	.0	6.0	6.0
Prince Edward Isle	470,300	150	2.0	.0	2.0
Saskatchewan	8,325,665	2,903	9.0	20.5	29.5
Total Land	166,597,259	44,083	52.0	411.1	463.1
Marine					
Undesignated	31,654,800	25,673	.0	32.0	32.0
East Coast	26,500,000	31,410	.0	24.0	24.0
West Coast	361,138	534	.0	8.2	8.2
Total Marine	58,515,938	57,617	.0	64.2	64.2
Total Canada	225,113,197	101,700	52.0	475.3	527.3

Table 10. Petroleum seismic activity in Mexico.**

Area	Acquisition Costs (US$)	Line-miles	Crew-months Company	Crew-months Contract	Total months
Land					
Various	5,298,636	2,740	.0	94.3	94.3
Total Mexico	5,298,636	2,740	.0	94.3	94.3

**Incomplete data

Table 11. Total worldwide expenditures on gravity and magnetic surveys in US$ (thousands).

Area	Petroleum	Minerals	Engineering	Geothermal	Groundwater	Oceanography	Research	Total
International	348					130	912	1,390
U.S.A.	19,801	783	493	923			1,677	23,679
Canada	955	1,331	4			45	8	2,343
Mexico**	110	465					40	615
South America	731	300					240	1,271
Europe	1,172	160	280	34				1,647
Africa	3,170	3,267	19		3		375	6,835
Middle East	1,325							1,325
Far East	149	150	20	3,040				3,359
Australia/ New Zealand	164	3,821			1		11	3,997
Total	27,928	10,278	816	3,997	4	175	3,263	46,464

**Incomplete data

Table 12. Total worldwide expenditures on airborne surveys in US$ (thousands).

Area	Petroleum	Minerals	Engineering	Geothermal	Research	Total
International	348					348
U.S.A.	11,892	2,357	58	255	1,000	15,562
Canada	580	5,145			370	6,096
Mexico**	110	400				510
South America	2,540	710				3,250
Europe		806	150		12	968
Africa	4,032	5,453				9,485
Middle East	328	575				903
Far East	2,339	150		6,243		8,732
Australia/ New Zealand		3,953				3,953
Total	22,169	19,551	208	6,498	1,382	49,808

**Incomplete data.

Table 13A. Western Hemisphere airborne activity in US$ (thousands).

	International		USA		Canada		Mexico**		South America	
Survey method	Line-miles	Cost	Line-miles	Cost	Line-miles	Cost	Line-miles	Cost	Line-miles	Cost
Gravity			[182,800]	3,725						
Magnetic	17,444	348	455,820	7,900	84,107	1,086	33,500	510	19,085	680
Combined EM/Mag.			19,376	1,279	23,098	1,329				
VLF			350	20						
Input			12,000	567	45,700	2,514			8,200	410
Radioactivity			180	16	24,500	520				
Remote Sensing (side-scan radar)			71,400§	2,055					48,600§	2,160
Other					17,900	646				
Total	17,444	348	487,726 [182,800] 71,400§	15,562	195,305	6,096	33,500	510	27,285 48,600§	3,250

[No. of stations]. §Square miles. **Incomplete data.

Table 13B. Eastern Hemisphere airborne activity in US$ (thousands).

	Europe		Africa		Middle East		Far East		Australia/NZ	
Survey method	Line-miles	Cost	Line-miles	Cost	Line-miles	Cost	Line-miles	Cost	Line-miles	Cost
Magnetic	7,359	220	268,462	5,682	15,200	328	68,087	2,965	222,064	3,568
Combined EM/Mag.	4,700	719	21,580	1,953					2,950	385
Radioactivity	555	12	31,481	708	24,778	575				
Remote Sensing (side-scan radar)	700	16	166,785§	1,142			690,390§	5,767		
Total	13,314	968	321,523 166,785§	9,486	39,978	903	68,087 690,390§	8,732	225,014	3,953

§Square miles.

Table 14A. Western Hemisphere land mining activity in US$ (thousands).

Survey method	USA		Canada		Mexico**		South America	
	Line-miles	Cost	Line-miles	Cost	Line-miles	Cost	Line-miles	Cost
Seismic reflection P-wave	37	77	30	20			90	587
Seismic refraction	8	59	70	58				
Gravity	227	125	415	506	38	25		
Magnetic	574	183	2,290	318	213	40		
Resistivity	9	10	100	25	345	100		
Self-potential	8	2	15	1				
Electromagnetic	674	301	2,914	927	89	93		
Combined EM/Mag.	86	29	1,093	592				
VLF	123	45	708	96				
Induced polarization	345	594	1,226	1,365			1	23
Radiometric (gamma ray)	232	413						
Magnetotelluric	125	622	7	28				
Other	17	11	60	200				
Total	2,465	2,476	8,928	4,140	685	258	91	610

**Incomplete data.

Table 14B. Eastern Hemisphere land mining activity in US$ (thousands).

Survey method	Europe		Africa		Australia/NZ	
	Line-miles	Cost	Line-miles	Cost	Line-miles	Cost
Seismic reflection P-wave	490	6,851			34	215
Seismic refraction					2	5
Gravity	220	90	659	191	400	218
Magnetic			2,049	264	305	34
Resistivity			6	2		
Self-potential			40	20		
Electromagnetic			430	261	483	374
Combined EM/Mag.	25	27			505	520
VLF	50	15	201	18		
Induced polarization	50	63	358	287	380	381
Radiometric (gamma ray)			1,090	66		
Magnetotelluric			25	6	108	309
Total	835	7,047	4,858	1,118	2,217	2,058

Table 15. Worldwide groundwater and engineering activity.

Survey method	Area			Time*		Cost
	Line-miles	Stations	Footage	Crew-months	Man-months	US$ (thousands)
Seismic reflection P-wave	37,452	150		105.0	49.2	19,866.7
Seismic reflection S-wave	180			1.0		60.0
Seismic refraction	577	166	7,500	46.6	53.2	1,215.2
Gravity		8,012		3.1	30.0	548.2
Magnetic	10,694	3,300		1.2	6.0	272.5
Resistivity	2,305	3,542	59,583	85.0	11.2	1,660.8
Self-potential	11	905	3,062	.1	2.1	76.9
Sonic/velocity logging			45,582	9.7	1.0	203.7
Electromagnetic	1,722	740	70,800	39.4	38.6	2,022.6
Combined EM/Mag.	1				.2	4.0
Induced polarization	20			5.0		20.0
Electrical field	24			10.0		44.0
Radiometric (gamma ray)			28,140	1.0	6.3	71.2
Remote sensing	16			1.0		42.0
Temperature gradient			94,742		12.3	27.2
Other	25	100	110,286	10.2	27.5	534.3
Total	53,027	16,915	419,695	318.3	237.6	26,668.3

*Includes government and university activity.

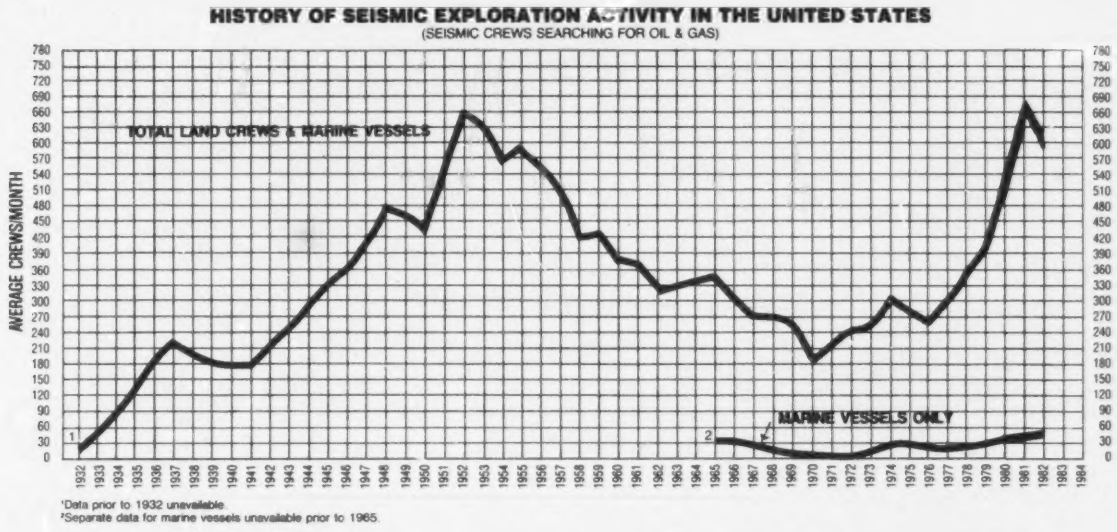

FIG. 5 History of seismic exploration activity in the U.S., 1932-1982. The total crews working in a given year is not synonymous with the crew-months worked that year.

Table 16. Worldwide geothermal activity.

Survey method	Area			Time*		Cost
	Line-miles	Stations	Footage	Crew-months	Man-months	US$ (thousands)
Seismic reflection P-wave	75			11.0		225.0
Gravity	2,075	2,702		36.0	3.5	927.6
Magnetic	73,443			28.1		3,070.0
Resistivity	22	44		4.3		60.2
Self-potential	269			3.6	.5	63.6
Electromagnetic	280			5.0		120.0
Earth current	70			3.0		45.0
Remote sensing (side-scan radar)	500,355§			3.0		3,427.4
Temperature gradient			30,200	41.4		222.0
Magnetotelluric		1,083		24.6		2,734.3
Other				2.0		40.0
Total	76,234 500,355§	3,829	30,200	162.0	4.0	10,934.1

*Includes government and university activity.
§Square miles.

Gravity and magnetic surveys

Table 11 shows worldwide expenditures for gravity and magnetic surveys. While there was a significant increase (over 500 percent) in the use of these tools for geothermal exploration, there were decreases in all other uses, giving us a net decline in activity of 17 percent from 1981. The Western Hemisphere decreased its use of these surveys by 5 percent while the Eastern Hemisphere declined 31 percent.

Airborne surveys

Statistical data on airborne surveys are shown in Tables 12, 13a and 13b. Expenditures for airborne surveys suffered a sharp drop (27 percent) in 1982. This decrease seems related to the decrease in mineral exploration reported. Magnetics is still the most popular airborne tool, with remote sensing and combined EM/Mag ranking second and third, respectively.

Land mining

Tables 14a and 14b report expenditures and methods utilized for land mining in the Western and Eastern Hemispheres. Reported usage of geophysical exploration for minerals using land methods was down from 1981. Both the Western and Eastern Hemispheres had approximately a 9 percent decline in activity. The largest decline occurred in South America.

Engineering, geothermal, groundwater, oceanography, and research

Table 15 reports engineering/groundwater activity. Table 16 contains world wide geothermal work. Average unit costs for all survey objectives, types, and methods can be found in Table 17. Groundwater activity is markedly lower than last

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Table 17. Worldwide average unit costs by survey objective, type, and method.

Survey objective, type, and method	Total* crew-months or (man-months)	Line-miles or (logged-footage) or [no. of stations]	Acquisition costs — US$	Avg. miles or (feet.) or [sta.]/month or (man-month)	Average cost/month or (cost/ man-month)	Average cost/mile or (foot) or [station]
Petroleum						
Land						
Seismic (P-wave)						
Dynamite	4,552.4	232,848	1,092,074,877	51	239,890	4,690
Compressed air	304.5	47,332	96,961,435	155	318,365	2,048
Gas exploder	48.0	1,752	9,878,600	36	205,804	5,638
Weight drop	96.3	10,550	27,178,475	109	282,227	2,576
Solid chemical	66.5	3,100	21,742,000	46	326,947	7,013
Vibratory	3,478.1	215,141	955,708,507	61	274,773	4,442
Other	17.0	1,122	4,482,037	65	262,721	3,994
Seismic (S-wave)						
Dynamite	17.5	319	1,045,527	18	59,744	3,269
Vibratory	29.7	690	8,901,213	23	299,704	12,900
Seismic (refraction)						
Dynamite	32.0	983	3,550,400	30	110,950	3,611
Compressed air	2.7	990	721,971	366	267,396	729
Vibratory	1.0	43	319,725	43	319,725	7,401
Gravity	309.6	76,602	9,912,504	247	32,011	129
Gravity	71.8	[59,710]	1,886,046	[831]	26,268	[31]
Gravity	(8.0)	[2,220]	24,000	[277]	(3,000)	[10]
Magnetic	47.6	6,179	732,160	129	15,381	118
Magnetic	6.3	[4,707]	58,108	[747]	9,223	[12]
Resistivity	3.5	42	55,000	12	15,714	1,310
Self potential	3.0	200	50,000	66	16,666	250
Electromagnetic	41.0	3,075	3,030,000	75	73,902	985
Induced polarization	33.6	483	1,350,725	14	40,140	2,796
Magnetotelluric	18.5	488	1,105,650	26	59,764	2,262
Magnetotelluric	8.5	[372]	1,233,322	[43]	145,096	[3,315]
Other	44.7	2,744	14,617,746	61	327,018	5,327
Other	(18.0)	[3,544]	360,000	[196]	(20,000)	[101]
Marine						
Seismic (P-wave)						
Compressed air	971.3	918,767	639,117,443	945	657,968	695
Electrical	(5.0)	1,150	410,000	(230)	(82,000)	356
Gas exploder	122.0	126,900	50,670,000	1,040	415,327	399
Implosive	85.5	53,872	36,385,600	630	425,562	675
Gravity	39.0	39,750	840,000	1,019	21,538	21
Airborne						
Gravity	5.0	[123,000]	3,000,000	[24,600]	600,000	[24]
Magnetic	97.6	631,450	11,476,035	6,464	117,486	18
R-S side-scan radar	6.4	476,820§	7,697,000	74,503§	1,202,656	16§
Drill hole						
Sonic/velocity logging	7.6	**	222,000	**	29,210	**
Sonic/velocity logging	(2.0)	**	60,000	**	(30,000)	**
Radiometric						
Neutron activation	(12.0)	(8,000)	185,000	(666)	(15,416)	(23)
Temperature gradient	(1.0)	(300)	20,000	(300)	(20,000)	(66)
Other	(18.0)	(15,000)	1,500,000	(833)	(83,333)	(100)
Minerals						
Land						
Seismic (P-wave)						
Dynamite	33.8	524	7,063,961	15	208,992	13,460
Dynamite	(18.0)	37	77,375	(2)	(4,298)	2,063

*Total includes government and university activity.
**Incomplete data.
§Square miles.

Table 17. Worldwide average unit costs by survey objective, type, and method. (cont.)

Survey objective, type, and method	Total* crew-months or (man-months)	Line-miles or (logged-footage) or [no. of stations]	Acquisition costs — US$	Avg. miles or (feet.) or [sta.]/month or (man-month)	Average cost/month or (cost/ man-month)	Average cost/mile or (foot) or [station]
Minerals, (cont.)						
Land						
Seismic (P-wave)						
Weight drop	2.0	30	20,000	15	10,000	666
Vibratory	7.2	90	590,000	12	81,944	6,555
Seismic (refraction)						
Dynamite	6.5	57	85,000	8	13,076	1,491
Dynamite	(2.7)	4	29,105	(1)	(10,507)	7,276
Weight drop	.5	20	8,000	40	16,000	400
Gravity	37.4	1,933	866,956	51	23,168	448
Gravity	7.5	[6,800]	193,000	[906]	25,733	[28]
Gravity	(12.0)	28	27,700	(2)	(2,308)	989
Gravity	(30.0)	[3,079]	70,100	[102]	(2,336)	[22]
Magnetic	72.0	3,984	501,961	55	6,966	125
Magnetic	6.0	[30,000]	30,000	[5,000]	5,000	[1]
Magnetic	(155.6)	1,455	298,960	(9)	(1,921)	205
Resistivity	5.1	358	108,453	69	21,058	302
Resistivity	(4.0)	103	29,000	(25)	(7,250)	281
Self potential	2.7	64	22,800	23	8,444	355
Electromagnetic	92.2	3,464	1,471,789	37	15,963	424
Electromagnetic	1.0	[105]	25,000	[105]	25,000	[238]
Electromagnetic	(45.4)	1,129	342,797	(24)	(7,550)	303
Electromagnetic	(30.0)	[1,990]	118,500	[66]	(3,950)	[59]
Combined EM/Mag	41.0	1,710	1,169,803	41	28,512	683
VLF	18.5	616	108,355	33	5,857	175
VLF	(6.7)	471	67,552	(70)	(10,082)	143
Induced polarization	134.6	2,188	2,545,165	16	18,902	1,163
Induced polarization	(95.0)	179	169,000	(1)	(1,778)	944
Radiometric						
Gamma ray	8.0	933	47,000	116	5,875	50
Alpha track	9.0	100	10,000	11	1,111	100
Neutron activation	16.0	231	408,305	14	25,519	1,767
Radiometric						
Gamma ray	(98.0)	59	6,600	(1)	(67)	110
Radiometric						
Gamma ray	(1.0)	[8,000]	8,000	[8,000]	(8,000)	[1]
Magnetotelluric	29.6	270	966,235	9	32,643	3,579
Other	3.6	78	107,447	21	29,197	1,372
Other	(10.5)	1,050	100,175	(100)	(9,540)	95
Marine						
Seismic (P-wave)						
Compressed air	1.0	670	630,000	670	630,000	940
Airborne						
Magnetic	78.4	420,042	7,753,789	5,356	98,875	18
Magnetic	(11.5)	37,020	507,000	(3,219)	(44,086)	13
Combined EM/Mag	27.4	66,704	5,445,670	2,431	198,529	81
Combined EM/Mag	(9.0)	5,000	220,000	(555)	(24,444)	44
VLF	.2	350	20,000	1,250	71,428	57
Input	13.1	65,900	3,492,300	5,003	265,170	52
Radioactivity	11.4	56,995	1,312,000	4,964	114,285	23
Radioactivity	(8.0)	2,000	150,000	(250)	(18,750)	75
Remote sensing						
Multispectral scanning	.6	100	4,800	167	8,000	47
Other	3.7	17,900	646,000	4,837	174,594	36

*Total includes government and university activity.
**Incomplete data.
§Square miles.

Table 17. Worldwide average unit costs by survey objective, type, and method. (cont.)

Survey objective, type, and method	Total* crew-months or (man-months)	Line-miles or (logged-footage) or [no. of stations]	Acquisition costs — US$	Avg. miles or (feet.) or [sta.]/month or (man-month)	Average cost/month or (cost/ man-month)	Average cost/mile or (foot) or [station]
Minerals, (cont.)						
Drill hole						
Magnetic	2.5	(49,414)	29,400	(19,766)	11,760	(1)
Resistivity	.6	(15,666)	24,000	(23,736)	36,363	(1)
Self potential	75.1	(521,503)	591,400	(6,941)	7,871	(1)
Sonic/velocity logging	1.0	**	12,000	**	12,000	**
Induced polarization	4.5	(81,993)	47,600	(18,220)	10,577	**
Induced polarization	(13.1)	(21,500)	231,000	(1,641)	(17,633)	(10)
Radiometric						
Gamma ray	2.6	(99,007)	56,000	(37,220)	21,052	**
Radiometric						
Gamma ray	(1.0)	(6,000)	7,000	(6,000)	(7,000)	(1)
Temperature gradient	.1	(2,113)	3,200	(21,130)	32,000	(1)
Other	1.0	(12,458)	43,000	(12,458)	43,000	(3)
Engineering						
Land						
Seismic (P-wave)						
Electrical	(17.0)	1,313	480,000	(77)	(28,235)	365
Weight drop	1.0	10	10,000	10	10,000	1,000
Weight drop	(1.0)	1	30,000	(1)	(30,000)	30,000
Vibratory	.2	1	55,000	6	220,000	36,666
Other	2.5	22	80,000	8	32,000	3,636
Other	(1.2)	2	35,700	(1)	(28,560)	15,521
Seismic (refraction)						
Dynamite	23.0	117	304,200	5	13,226	2,597
Dynamite	(11.7)	31	209,560	(2)	(17,911)	6,760
Weight drop	18.7	205	129,000	10	6,898	627
Weight drop	(8.6)	109	201,813	(12)	(23,357)	1,838
Weight drop	(5.9)	[166]	18,700	[28]	(3,169)	[112]
Solid chemical	(1.0)	1	10,000	(1)	(10,000)	10,000
Gravity	3.0	[2,527]	30,270	[828]	9,924	[11]
Gravity	(29.0)	[5,260]	515,000	[181]	(17,758)	[97]
Magnetic	(2.0)	3	20,000	(1)	(10,000)	6,666
Magnetic	(4.0)	[3,300]	27,000	[825]	(6,750)	[8]
Resistivity	9.0	120	153,000	13	17,000	1,275
Resistivity	8.1	[1,511]	106,500	[185]	13,067	[70]
Resistivity	(4.9)	[1,026]	57,250	[209]	(11,683)	[55]
Self potential	(.7)	11	14,000	(14)	(18,666)	1,272
Self potential	(1.2)	[905]	61,550	[724]	(49,240)	[68]
Electromagnetic	7.4	315	139,000	42	18,783	440
Electromagnetic	(16.1)	700	1,017,500	(43)	(62,964)	1,452
Remote sensing						
Other	.9	1	35,000	2	38,888	19,444
Other	2.0	[100]	40,000	[50]	20,000	[400]
Other	(12.9)	24	189,990	(1)	(14,727)	7,691
Marine						
Seismic (P-wave)						
Compressed air	10.0	4,000	2,000,000	400	200,000	500
Compressed air	(4.0)	450	490,000	(112)	(122,500)	1,088
Electrical	73.0	20,715	10,192,500	283	139,565	492
Electrical	(21.0)	1,248	1,080,000	(59)	(51,428)	865
Gas exploder	17.3	9,614	5,328,000	554	307,089	554
Implosive	.2	50	30,000	250	150,000	600

*Total includes government and university activity.
**Incomplete data.
§Square miles.

Table 17. Worldwide average unit costs by survey objective, type, and method. (cont.)

Survey objective, type, and method	Total* crew-months or (man-months)	Line-miles or (logged-footage) or [no. of stations]	Acquisition costs — US$	Avg. miles or (feet.) or [sta.]/month or (man-month)	Average cost/month or (cost/ man-month)	Average cost/mile or (foot) or [station]
Engineering, (cont.)						
Marine						
Seismic (S-wave)						
Compressed air	1.0	180	60,000	180	60,000	333
Seismic (refraction)						
Compressed air	(7.5)	28	144,000	(3)	(19,123)	5,124
Magnetic	.2	111	14,500	462	60,416	130
Resistivity	(1.0)	40	50,000	(40)	(50,000)	1,250
Airborne						
Magnetic	.6	10,560	208,000	17,600	346,666	19
Drill hole						
Resistivity	2.0	(40,000)	40,000	(20,000)	20,000	(1)
Sonic/velocity logging	9.7	**	183,761	**	18,944	**
Sonic/velocity logging	(1.0)	**	20,000	**	(20,000)	**
Radiometric						
Gamma ray	(4.6)	(11,344)	59,800	(2,466)	(13,000)	(5)
Other	(13.8)	(72,500)	188,700	(5,254)	(13,674)	(3)
Geothermal						
Land						
Seismic (P-wave)						
Dynamite	9.0	20	100,000	2	11,111	5,000
Vibratory	2.0	55	125,000	27	62,500	2,272
Gravity	22.0	2,075	574,000	94	26,090	276
Gravity	14.0	[2,291]	269,600	[163]	19,257	[117]
Gravity	(3.5)	[411]	84,000	[117]	(24,000)	[204]
Resistivity	1.0	22	28,000	22	28,000	1,272
Resistivity	3.3	[44]	32,200	[13]	9,757	[731]
Self potential	3.6	221	28,215	61	7,837	127
Self potential	(.5)	48	35,400	(96)	(70,800)	737
Electromagnetic	5.0	280	120,000	56	24,000	428
Earth current	3.0	70	45,000	23	15,000	642
Magnetotelluric	24.6	[1,083]	2,734,379	[43]	110,928	[2,524]
Airborne						
Magnetic	28.1	73,443	3,070,000	2,608	109,058	41
R-S side-scan radar	3.0	500,355§	3,427,431	166,785§	1,142,477	7§
Drill hole						
Temperature gradient	41.4	(30,200)	222,000	(729)	5,362	(7)
Groundwater						
Land						
Seismic (P-wave)						
Weight drop	2.5	[250]	30,000	[100]	12,000	[120]
Weight drop	(4.5)	6	22,500	(1)	(5,000)	3,461
Seismic (refraction)						
Dynamite	5.2	57	83,000	10	15,809	1,456
Weight drop	(4.0)	1	46,000	**	(11,500)	30,666
Solid chemical	(1.0)	2	5,000	(2)	(5,000)	2,500
Other	(14.0)	31	39,000	(2)	(2,785)	1,258
Gravity	(1.0)	[225]	1,000	[225]	(1,000)	[4]
Magnetic	.5	20	3,000	40	6,000	150
Resistivity	49.7	2,113	942,000	42	18,953	445
Resistivity	11.9	[425]	228,600	[35]	19,210	[537]
Resistivity	(3.0)	[580]	40,000	[193]	(13,333)	[68]

*Total includes government and university activity.
**Incomplete data.
§Square miles.

Table 17. Worldwide average unit costs by survey objective, type, and method. (cont.)

Survey objective, type, and method	Total* crew-months or (man-months)	Line-miles or (logged-footage) or [no. of stations]	Acquisition costs — US$	Avg. miles or (feet.) or [sta.]/month or (man-month)	Average cost/month or (cost/ man-month)	Average cost/mile or (foot) or [station]
Groundwater, (cont.)						
Land						
Electromagnetic	32.2	644	645,000	20	20,031	1,001
Electromagnetic	(17.5)	63	76,000	(3)	(4,342)	1,196
Electromagnetic	(4.0)	[740]	100,000	[185]	(25,000)	[135]
Combined EM/Mag	(.2)	2	4,000	(10)	(20,000)	2,000
Induced polarization	5.0	20	20,000	4	4,000	1,000
Electrical field	10.0	24	44,000	2	4,400	1,833
Other	(.8)	4	7,500	(5)	(9,375)	1,875
Marine						
Seismic (P-wave)						
Electrical	(.5)	11	3,000	(22)	(6,000)	272
Drill hole						
Resistivity	3.0	**	15,000	**	5,000	**
Resistivity	1.3	(17,796)	20,846	(13,689)	16,035	(1)
Resistivity	(.5)	(1,787)	1,904	(3,574)	(3,808)	(1)
Self potential	.1	(3,062)	1,375	(30,620)	13,750	(1)
Radiometric						
Gamma ray	1.0	(10,570)	1,608	(10,066)	1,531	**
Radiometric						
Gamma ray	(1.7)	(6,226)	9,792	(3,557)	(5,595)	(1)
Temperature gradient	(12.3)	(94,742)	27,231	(7,702)	(2,213)	**
Other	6.0	(56,516)	56,590	(9,419)	(9,432)	(1)
Oceanography						
Marine						
Seismic (P-wave)						
Compressed air	4.1	9,648	1,326,000	2,313	317,985	137
Electrical	3.9	13,090	2,555,500	3,330	650,254	195
Electrical	(.5)	2,800	200,000	(5,600)	(400,000)	71
Implosive	19.0	24,940	3,920,000	1,306	205,343	157
Magnetic	.5	2,130	130,000	4,260	260,000	61
Research						
Land						
Seismic (P-wave)						
Dynamite	8.5	157	820,000	18	96,470	5,222
Compressed air	2.0	3	28,000	1	14,000	9,333
Vibratory	16.2	861	3,850,176	53	236,933	4,467
Passive monitoring	.5	[15]	5,000	[30]	10,000	[333]
Other	3.0	28	90,000	9	30,000	3,214
Seismic (S-wave)						
Dynamite	1.0	20	5,000	20	5,000	250
Vibratory	5.2	137	1,321,773	26	254,187	9,605
Seismic (refraction)						
Dynamite	3.0	17	110,000	5	36,666	6,321
Dynamite	.2	[30]	1,000	[120]	4,000	[33]
Solid chemical	5.0	444	1,399,742	88	279,948	3,152
Passive monitoring	(.2)	150	1,000	(600)	(4,000)	6
Other	1.0	[200]	2,575	[200]	2,575	[13]
Gravity	14.3	2,569	674,500	179	47,167	262
Gravity	5.7	[1,520]	43,500	[264]	7,565	[28]
Gravity	(41.9)	[9,115]	112,800	[217]	(2,692)	[12]

*Total includes government and university activity.
**Incomplete data.
§Square miles.

Table 17. Worldwide average unit costs by survey objective, type, and method. (cont.)

Survey objective, type, and method	Total* crew-months or (man-months)	Line-miles or (logged-footage) or [no. of stations]	Acquisition costs — US$	Avg. miles or (feet.) or [sta.]/month or (man-month)	Average cost/month or (cost/ man-month)	Average cost/mile or (foot) or [station]
Research, (cont.)						
Land						
Magnetic	.3	1	30,200	4	100,666	23,230
Magnetic	1.0	[2,000]	15,000	[2,000]	15,000	[7]
Magnetic	(18.1)	[4,650]	90,075	[256]	(4,976)	[19]
Resistivity	5.1	1,005	227,000	197	44,509	225
Self potential	(2.5)	2	25,000	(1)	(10,000)	10,000
Electromagnetic	.7	[41]	80,000	[54]	106,666	[1,951]
Electromagnetic	(5.0)	[2,120]	70,000	[424]	(14,000)	[33]
Induced polarization	7.7	133	211,000	17	27,225	1,586
Magnetotelluric	4.8	[240]	291,230	[50]	60,673	[1,213]
Other	5.4	[178]	46,100	[33]	8,537	[259]
Marine						
Seismic (P-wave)						
Compressed air	12.3	45,851	2,982,150	3,727	242,451	65
Compressed air	(1.5)	50	85,000	(33)	(56,666)	1,700
Electrical	3.0	1,700	250,000	566	83,333	147
Seismic (refraction)						
Compressed air	.3	380	70,000	1,085	200,000	184
Solid chemical	1.5	630	210,000	420	140,000	333
Gravity	3.3	7,000	265,000	2,089	79,104	37
Magnetic	13.0	61,465	1,032,000	4,728	79,384	16
Airborne						
Gravity	1.7	[59,800]	725,000	[34,171]	414,285	[12]
Magnetic	3.3	18,615	275,500	5,640	83,484	14
Radioactivity	2.9	22,500	370,000	7,758	127,586	16
Remote sensing						
Multispectral scanning	.5	600	12,000	1,200	24,000	20
Drill hole						
Sonic/velocity logging	1.0	**	10,000	**	10,000	**
Electromagnetic	1.0	**	50,000	**	50,000	**
Resistivity	(1.0)	(200)	5,000	(200)	(5,000)	(25)
Other	(6.5)	(1,700)	27,000	(261)	(4,153)	(15)

*Total includes government and university activity.
**Incomplete data.
§Square miles.

year but the significant increase in engineering easily offsets that and gives us a combined increase of 51 percent in these two areas (see Table 15). Geothermal activity is down 20 percent which can be attributed to the reduction in drill hole work. Research and oceanography are both up this year.

Summary

As I mentioned in my introduction, there was a 30 percent increase in the amount of data reported this year over last. The only geographic area where we did not receive complete data was Mexico. Except for this one area this report is more complete than any of the previous 5-10 year reports. It is with great excitement that I look forward to future reports knowing that they have the same potential to be as complete as this report.

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